Water spectrum

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Front cover—Osprey returns to nest in top of palm tree at Lake Ocklawaha.

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The Corps of Engineers has long been an advocate of applying treated wastewater to the land for agricultural and other purposes. To test the practical application of this concept, Deer Creek, Ohio was selected as a natural laboratory.

The Living Filter Comes to Deer Creek

by David J. Lambert and William R. Dawson

Relatively unknown outside of Ohio, Deer Creek Lake is on the verge of becoming a land treatment Mecca for wastewater scientists in the months ahead. Located in the south-central area of the State, this pilot project will use the wastewater effluent from a 232-unit camping area for application on nearby agricultural land. The objective: to meet the water quality goals set forth in the Federal Water Pollution Control Amendments of 1972.

The test site consists of a 1,277-acre lake and its surrounding land area. It was created in 1968 primarily as a flood control reservoir to reduce flood stages at downstream points along the Scioto River, which the creek joins 21 miles below Deer Creek Dam, and the Ohio River, which the Scioto meets 105 miles to the south.

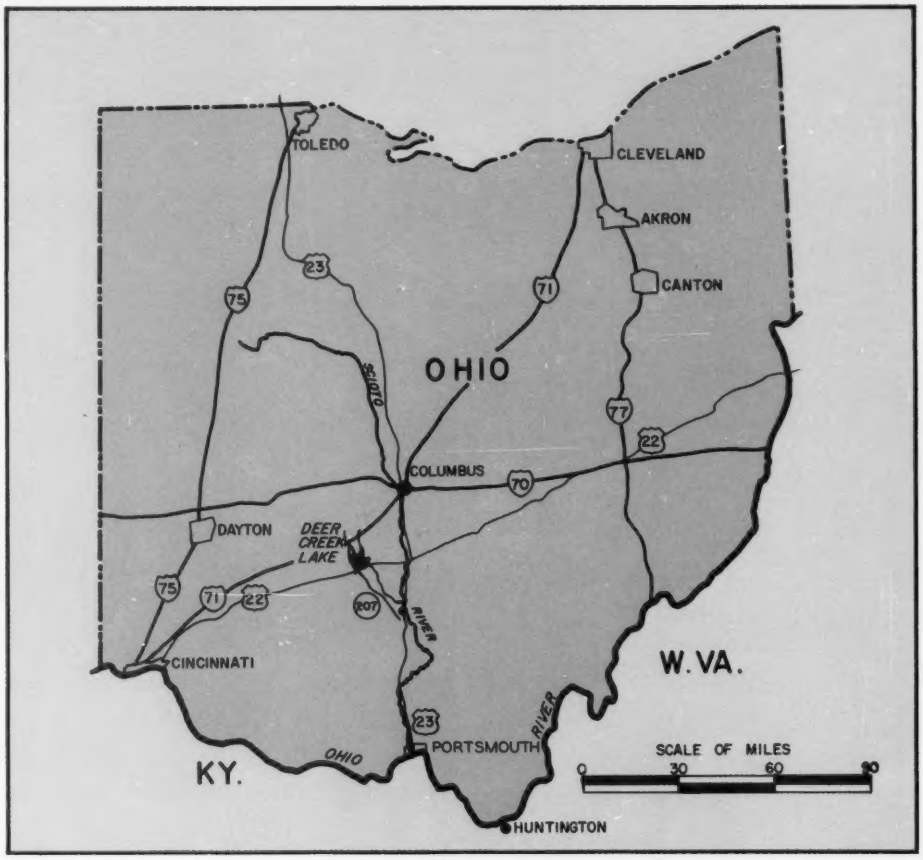
Situated only 30 miles southwest of the State capital at Columbus, and 35 miles northwest of Chilicothe, Deer Creek Lake's accessibility to large population centers and major highway systems has made it a popular boating and camping site. In addition, it is convenient for the Ohio Department of Natural Resources, with whom the Huntington District of the Corps is cooperating in developing, operating and monitoring this project.

The camping site, opened in the spring of 1974, will accommodate trailers and tents and was an immediate success, reaching peak visitation of 16,518 campers in July.

To provide sanitary facilities for the visitors, a central sewage dump station for trailers was installed along with multiple slop drains, six comfort stations and four wash houses. The wash houses will supply the largest volumes of wastewater since each is equipped with two washers and dryers, six shower stalls and six to eight wash basins.

All of these wastewater sources will feed into two lift stations, located at the camping site, through underground drains and will be pumped to the stabilization lagoon, where

Both authors are from the Huntington (W.Va.) District of the Corps. Mr. Lambert is chief of the Design Branch in the Engineering Division. Mr. Dawson is a civil engineer in the Urban Studies Section of the Planning Branch.



Deer Creek Lake lies 30 miles southwest of Columbus, and close enough to Interstate 70 for easy visitor access.

the wastewater will enter the lagoon from the bottom.

The lagoon is part of the simple two-stage waste treatment system designed prior to the passage of the 1972 Amendments. If only the two lagoon system continued to be used, the quality of the effluent may not have met the Federal standards by 1977. Campers comprised only a small percentage of the total visitors to Deer Creek Lake as current data indicates 1.6 million visitor days during the 1974 season.

While other Corps recreational sites certainly share the need for an expanded waste treatment system, a choice had to be made. Deer Creek Lake had two advantages: there was a new camping site; and there was an adjacent tract of land that had been previously cultivated and farmed, providing the necessary flat slopes, ideal for surface drainage. There is also a sufficiently large vegetative buffer zone of weeds and trees and ample distance between the camping site and the lagoons to protect the site from adverse wind sprays once spray application of wastewater began. The irregular shaped buffer zone is about 1,000 to 1,200 feet wide at varying points.

Once Deer Creek was selected as the test project, the nearby Circleville staff of the Soil Conservation Service was consulted about the soil percolation capabilities for this specific site in order to determine whether the soil would be more likely to accept infiltration or overland flow of the wastewater.[1] When it was learned that the site in question had poor soil drainage in its natural state, this condition was remedied by installing an underdrain collection system similar to those in common use by local farmers.

The decision to use spray distribution of the effluent was based on the need to apply the wastewater over the entire area at a rate easily regulated. This is important because the Deer Creek camping areas will remain open all year and the volume of wastewater pumped to the lagoons will fluctuate sharply with the number of seasonal and weekend visitors.

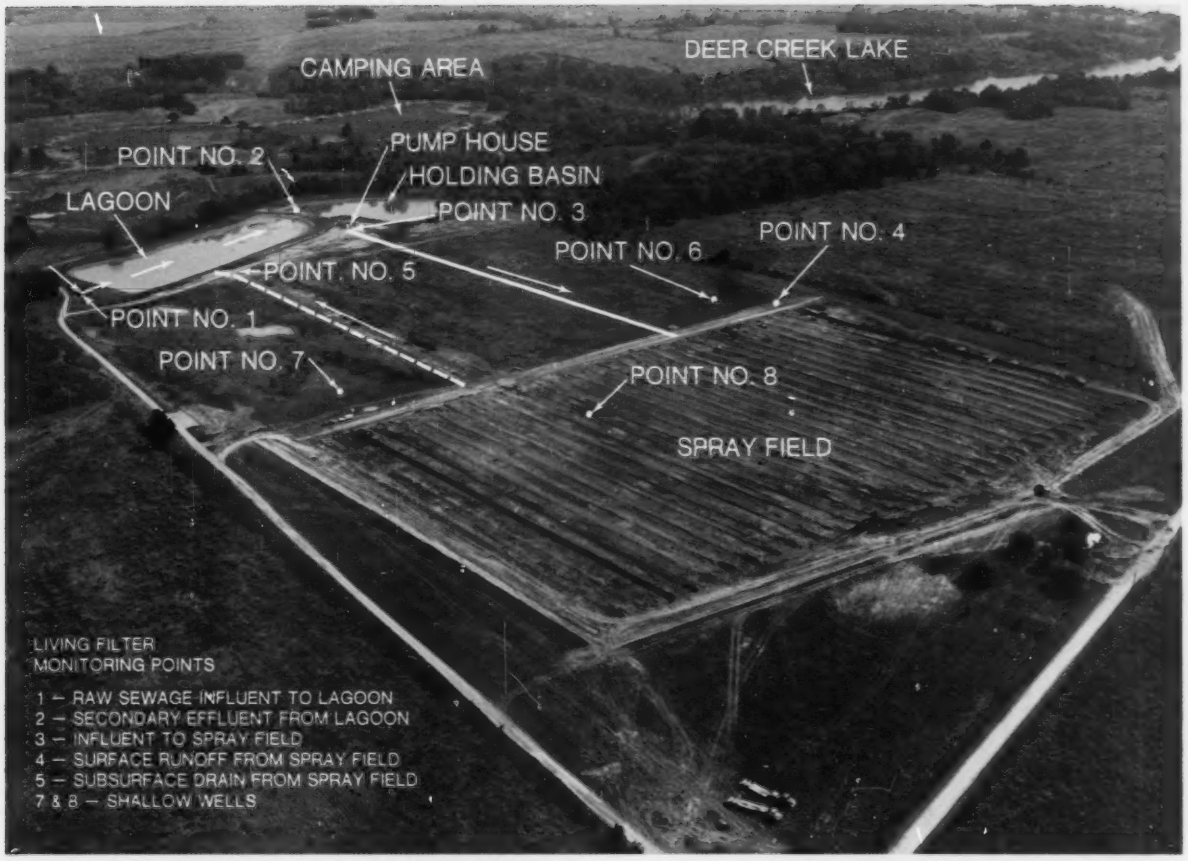
Preliminary designs and cost estimates were prepared for four different spray systems. Of the four designs evaluated, the system selected relies on equal spacing of spray nozzles for uniform hydraulic loading rather than rotating spray bars, unequally spaced nozzle rows or spraying from the upper end of the sloping field in order to create an overland flow.

Although the uniform hydraulic loading system is not the least expensive design, it yields the best overall conditions aesthetically as well as in terms of soil infiltration and cultivation, plant transpiration and liquid evaporation. Despite the buffer zone, aerosol drift was considered a potential problem, but one which could be minimized by selecting calm days for the spray application.

Design

The complete treatment system will be composed of a stabilization lagoon, chlorine contact chamber, holding basin, pump intake, distribution piping, and 12-acre spray field. Runoff from higher ground will be diverted from the field by ditching. A small amount of overland runoff resulting from the spray application of the wastewater and rainfall will collect in ditches at the lower end of the field while the underdrainage system collects water percolating through the

[1]See "Overland Flow" by P. G. Hunt, *Water Spectrum*, Vol. 5, No. 4, 1973, and "High-Rate Land Treatment" by Herman Bouwer, *Water Spectrum*, Vol. 6, No. 1, 1974.



Aerial view of spray field under construction with the lagoon and holding basin in background and the 8 monitoring points for the proposed land treatment system.

soil. The water from the underdrains will be directed back to the stabilization lagoon for recycling or can be diverted to Deer Creek Lake should the quality be determined adequate at this point.

The lagoon and holding basin are part of the original two-lagoon sewage treatment system installed at Deer Creek in 1973 to handle 46,000 gallons per day (gpd), which was the anticipated maximum weekend flow to be pumped from the 232 sites at the Deer Creek Camping Area. The primary lagoon was designed to hold 73 days of maximum flow at normal depth and could be raised 2 feet to store an additional 60 days. A secondary lagoon, originally intended to polish the effluent from the first, was converted to a holding basin capable of storing 62 days of maximum flow. The chlorination point was changed from the outfall of the holding basin (the old second lagoon) to a new contact chamber located between the lagoon and the holding basin.

Partially treated wastewater will be pumped from the holding basin at 560 gallons per minute (gpm) to the 12-acre spray field. This will provide an average application of 0.1 inch an hour. However, pumping will be limited to 10-hour periods so that no more than 1 inch is applied a week. The spray field's natural slope, averaging 1 percent, was left undisturbed in order to maintain the existing soil profile. Moving the earth to achieve a more uniform grade also would have made the soil profile characteristics less predictable. The only exception was the trenching necessary during construction to install the underdrain system.

There is a great deal of flexibility designed into this spray system. Any two of the three units in the pump house can accommodate the design flow of 560 gpm, leaving the third as a standby pump. Also, the entire flow of 280 gpm from one pump can be sprayed into any of the four equally sized 3-acre parallel sections into which the spray field is divided. Furthermore, each pump is equipped with individual intake screens so that each intake can be back flushed by the flow from the other pumps should the screens become clogged.

The actual application rate would reach 0.2 inch an hour if the spray were not alternated among four sections of the field by timers connected to remotely controlled electric solenoid valves. This arrangement limits each section to 15-minute applications separated by 15-minute rest intervals. We expect this provision for alternating flow to be most advantageous when agronomy studies are begun on the spray field. Each section will be served by four, 4-inch header pipes with 14 risers and sprinklers spaced at 40-foot centers on the headers. Landscaping considerations prompted placement of all headers and supply lines underground, not only to make the area more aesthetically acceptable, but also to ease the cutting, trimming and harvesting of the vegetative growth.

The underdrainage collection system will be used to relieve ponding and allow early spring application of wastewater. These drains were placed parallel to the spray header lines on 30-foot centers. Each drain consists of a 6-inch corrugated, flexible plastic pipe with a filter sleeve. Depending on its quality, the flow from the collection system can be diverted to the stabilization lagoon for recycling or piped into Deer Creek Lake.

Monitoring

The monitoring system will serve a dual purpose. First, it will insure the smooth operation of the land treatment system. Second, it will provide data to assist in the answering of research oriented questions. Eight planned monitoring points are located on the accompanying schematic and superimposed over the aerial photo of the spray field.

The flow of raw sewage will be measured at point 1, where a device activated by the startup of the raw sewage pump also will collect a composite sample for quality analysis. Point 2 sampling will monitor lagoon effluent for comparison with point 1 samples. This monitoring point is also automatic, activated by a timing device. Composite samples will be collected at point 3 when the pump is activated that transports wastewater to the spray irrigation field. The purpose will be to measure the quality of the wastewater prior to the spraying. Flow will also be recorded at this monitoring point to determine the quantity of the effluent moving to the spray field.

Points 4 and 5 will have automatic flow recording devices to measure overland runoff and subsurface drainage, respectively. Since the system is designed for wastewater infiltration into the soil, the excess water collected from overland flow will be attributed to rainfall. Grab samples will be collected at both points whenever it is deemed necessary to determine quality. The flow at point 4 will determine if flowing over a spray irrigation site adversely affects rain water quality. The quality of the renovated wastewater at point 5 will dictate whether the water meets advanced treatment requirements, and can be discharged into Deer Creek Lake, or must be recycled to the stabilization lagoon for further treatment. Ohio Department of Natural Resources will set up the decision making process for this monitoring point.

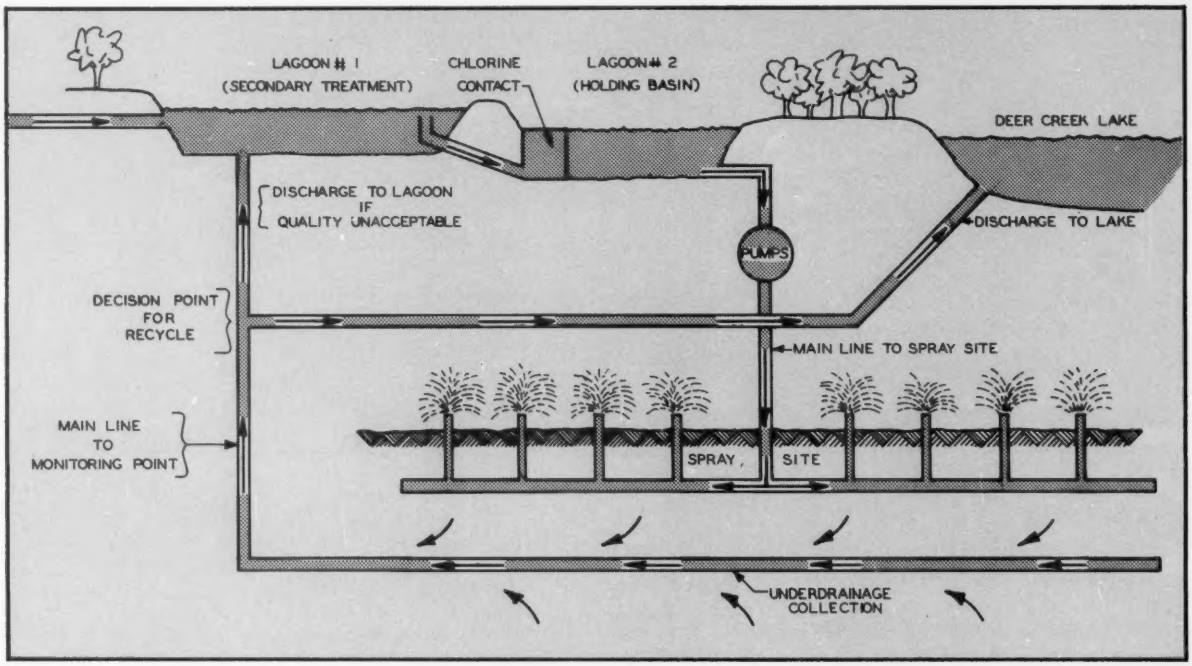
Monitoring points 6, 7 and 8 will consist of shallow wells where the level of the phreatic water surface will be visible. These wells will also provide convenient sites for withdrawing local grab samples with which to measure the effect of spray irrigation on ground water quality.

Each of these monitoring points is expected to provide information which can be applied to the design of more efficient land treatment sites in the future.

Crop and Soil Management

This project is expected to contribute to agricultural research needs also, since a crop and soil management program will become part of the future land treatment operation under the direction of the Ohio Department of Natural Resources and Agronomy Department of Ohio State University. Some specific objectives of this program are to:

- determine the amount of wastewater which can be applied without encouraging uptake of harmful quantities of toxic materials by the crop cover;



- determine appropriate crop rotation scheme for long term application;
- determine effect on the soil's capability to support agriculture after long term application;
- determine climatological effects on the crops by applying wastewater on a multiseasonal basis;
- determine if land treatment is better suited than other systems for handling intermittent loadings characteristic of recreation areas.

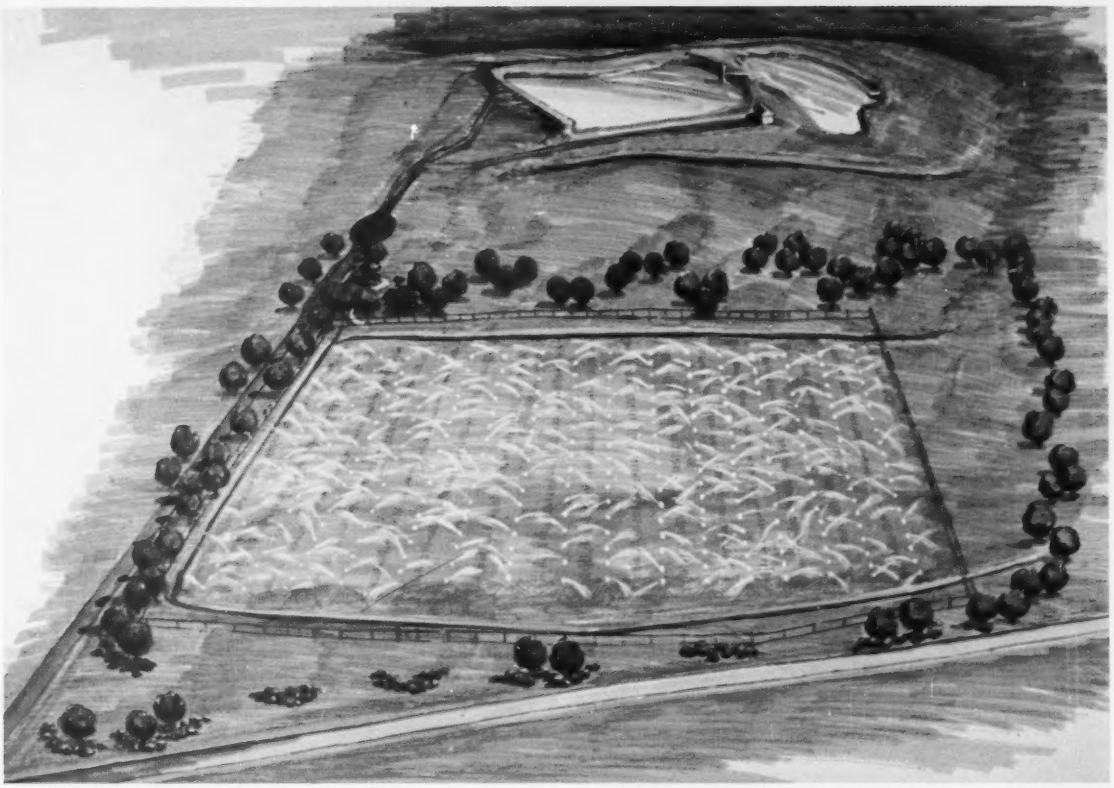
Working within the basic concept of a four-section spray irrigation field, the planting pattern recommended by the State and university is:

Section 1 — alfalfa
Section 2 — reed canary grass
Section 3 — rotational planting of wheat and soybeans
Section 4 — tree seedlings

Using this initial planting pattern, the agricultural as well as the wastewater renovation characteristics can be evaluated for each section and the entire system. Once the basic data is collected and evaluated, alternative crop plans can be utilized for either system improvement or further demonstration purposes.

Buffer zone separates the 232 unit camping area in foreground from lagoon, holding basin and spray field. Deer Creek Lake is visible in background.

Closeup of Deer Creek camping area, primary source of wastewater effluent for this summer's land application treatment.



Artist's concept of total system as it will appear this summer with spray system in foreground.

Innovative contractor installed flexible underdrain pipe in single operation with unusual trenching machine attachments. Contractor added bottom smoother, a sand hopper, underdrain piping bracket and spring-loaded roller (automobile wheel) to seat the pipe into sand.

Trenching machine hopper being filled with sand for bedding the underdrain pipe.

The Agreement

Each phase of the project's operation will become the responsibility of that group possessing the most expertise in that type of research among the three participating entities: the Ohio Department of Natural Resources, Ohio State University (under agreement with the Ohio Department of Natural Resources) and the Huntington District of the Corps. The operating agreement separates these responsibilities in the following manner.

Ohio's Department of Natural Resources will withdraw daily samples from all monitoring points, deliver the samples to the Ohio State University Laboratory, and operate the spray system in accordance with the Corps' operational manual.

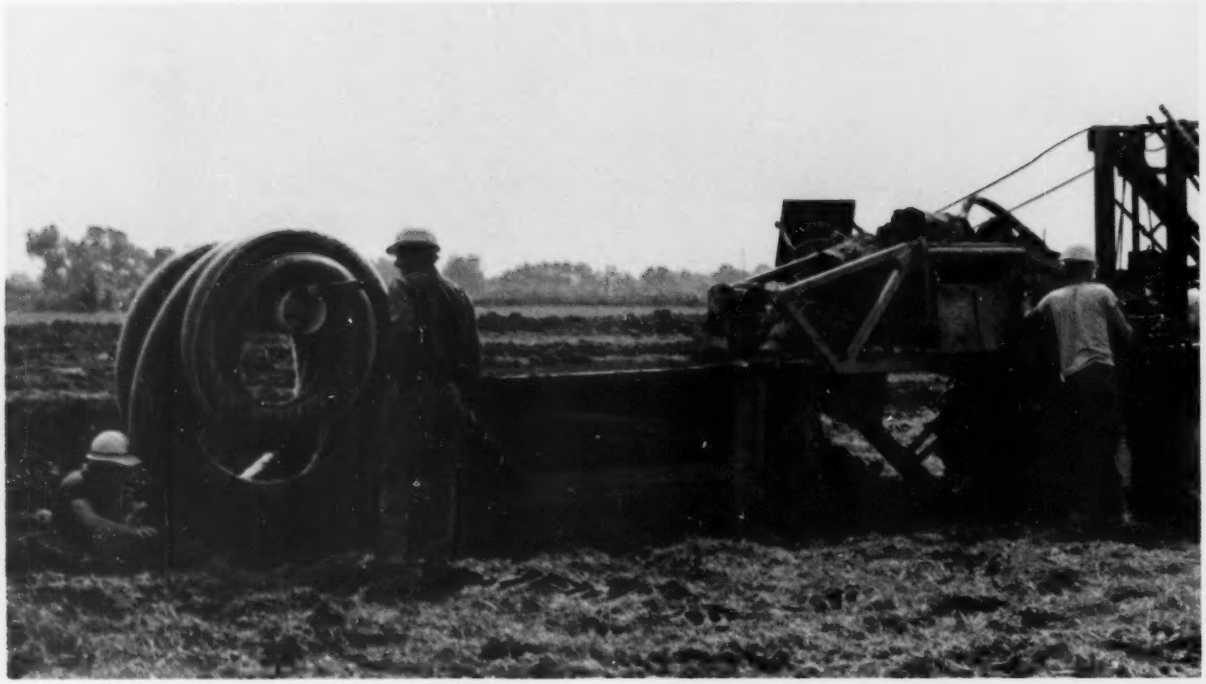
Ohio State University will analyze the samples, report the results, prepare a crop management plan, plant the crops, observe and test crop growth, gather other information deemed necessary for crop evaluation, provide technical assistance, periodic evaluations and an annual report.

The Huntington District will develop an operations manual, maintain the operating equipment for the first 5 years, and provide "baseline" data on the quality of effluent from the underdrain collection system prior to any spraying. After 5 years, these responsibilities will be shifted to the Ohio Department of Natural Resources.

Benefits

The prime benefit from this demonstration project, on the basis of results, will be to design and construct systems capable of treating larger quantities of wastewater. Without having actually operated the system, it may be somewhat speculative to predict other benefits; however, there is reasonable justification for predicting the following results within a certain range.

The first of these benefits may be the strong possibility that there will be no effluent discharge from the underdrain system during the June through August prime public use season. Should this prediction not be achieved due to weather conditions, the next expectation is that the effluent that does discharge from the system will meet the 1985 water quality standards. This benefit will be based on the fact that the system constructed at Deer Creek has both tremendous flexibility and renovative capacity.



Excavation, bedding and installation of underdrain takes place in single operation at rate of 300 feet an hour.

The second benefit will be enchancement of crop growth through uptake of nutrients in the effluent. Growth and nutrient uptake will be monitored and the resultant data will not only be used to alter this system but also applied to any subsequent systems.

The comprehensive monitoring system being installed should aid in the evaluation of land treatment systems in general, and can be considered a third benefit.

Fourth, the data gathered from this system will provide the basis for a better approach to designing similar systems. If, as postulated, the Deer Creek system meets the 1985 water quality standard called for in the 1972 Amendments, a sanitary engineer would be in a position to design a cost-effective system for projects of this magnitude.

The fifth benefit, and quite possibly the most comprehensive, will be the anticipated public acceptance of this wastewater management project. Our Nation cannot hope for a large scale advancement in this field until this acceptance becomes a fact. While people involved in technological pursuits recognize the potential commercial value of sewage effluent, this value has not made a favorable impression on the general public. In fact, the public has developed a decided aversion or apathy to the entire field of sewage treatment. Therefore, one of the equally important goals — aside from accomplishing the desired treatment — is to demonstrate to the public that land application of sewage effluent need not be an unsightly operation with offensive odors accompanying it, and that this method of application is effective in insuring a better water quality.

Public Involvement

An orderly public involvement plan has been formulated in order to reach the public. This plan highlights three facets of the program. First, this system may demonstrate that land application may be an even more acceptable alternative than conventional treatment methods. Second, this system may demonstrate that land application is a viable means of putting wastewater to a beneficial use. Third, the data on Deer Creek will be documented and made available to both the technical disciplines and the general public.

Design plans have been completed for an on-site observation shelter that will overlook the lagoons and spray field. Inside the shelter will be placed two push-button activated slide-talk presentations using video tapes coordinated with recorded educational material. One talk will describe and display the schematic layout of the wastewater treatment system for those who have an interest in this subject; the other talk will describe the various recreation facilities available to the public at Deer Creek. There will also be site photographs, descriptive brochures and guided tours.

A movie of the site is being produced by the Office of the Chief of Engineers for the more remote general public that may equally be interested in the technical aspects of the system. The film will give a complete history of the project from the start of construction in July 1974 through installation of the monitoring equipment, and includes scenes of actual spray irrigation.

Only 13 months elapsed from the initial request for the project until construction was completed in May 1975. The rapidity with which the project was prepared for its operational phase can be attributed to the effective coordination among the State and Federal agencies involved. Such active interest in the project will soon be rewarded. In a few months, the new land treatment system will have experienced its first summer time peak loading and collected its initial data base. Then we will know for sure that its benefits match our predictions. ■

LEGACY OF WILDLIFE

by Robert L. Solheim

Wildlife management at Corps lakes is tailored to fit those species whose natural habitats are within the region served. The following article treats the projects found most suitable in the Southeast by the Corps' South Atlantic Division. A preceding wildlife article, covering the Missouri River Basin, appeared in the Vol. 6, No. 3, 1974 issue.

It is May 1539. A boat loaded with helmeted conquistadors eases into the shore and the men quickly unload their supplies. This group of soldiers, headed by Spanish nobleman Hernando De Soto, is part of the 600-man expedition disembarking onto the western coast of Florida. They have come on a quest for gold.

The expedition moves inland through the dense foliage of subtropical Florida. Trees decked with hanging moss are left behind as the expedition marches across the Georgia and South Carolina piedmont, reaching the mountains of North Carolina in its determined search for gold. Steadfast in purpose, this small army then turned south, also exploring the forested hills of Alabama and Mississippi.

Lasting 4 years and covering 4,000 miles of uncharted terrain, the incredible journey, which cost the life of De Soto and more than half of his men, was a failure — no gold was found. It was not until years after that the real legacy of De Soto's journey was uncovered. The reports that the survivors of the expedition brought back indicated the land they explored was rich in things other than gold; the rivers were alive with fish, the valleys were fertile, and the forests provided shelter for an abundance of game.

Today the country explored by De Soto and his conquistadors in the 16th century contains industrial complexes, corporate farms and multistory housing developments for the 24 million residents within this six-state area. Indian trails have been turned into freeways and manmade lakes now exist on the rivers once crossed by De Soto's expedition. Thirty-three of these lakes are water resource projects constructed and managed by the Corps' South Atlantic Division. They provide flood control, aid navigation, produce electric power, and furnish water supply, recreation and fish and wildlife enjoyment for the Nation.

Many governmental groups, including the Corps, are working together to preserve De Soto's legacy. Public lands acquired for Corps water resource projects are being managed to preserve and enhance these renewable types of resources. Cooperative management programs are being aggressively pursued to insure that one of the most important of these resources — wildlife — will be available for the enjoyment of future generations.

As the population within the South Atlantic Division continues to increase, the maintenance of wildlife species and populations becomes increasingly difficult. William Bartram was America's first native born naturalist to explore this region in 1773. He reported in his book, *Travels Through North and South Carolina, Georgia, East and West Florida,* the problem of maintaining wildlife in such a populous region:

"As for the animal productions, they are the same which originally inhabited this part of North America, except such as have been affrighted away since the invasion of the Europeans. The buffalo, once so very numerous, is not at this day to be seen in this part of the country; there are but few elks, and those only in the Appalachian Mountains."

During a recent interview Edward Carlson of the Georgia Game and Fish Division explained the current problem by saying: "You can look at the situation only one way under a rising population, and that is that the wildlife habitat is going to deteriorate as human populations increase pressures. The two just won't fit together in that respect. So it's going to require all the skill and ingenuity of a wildlife manager to hang in there at all and have any kind of a wildlife population, and it's going to require intensive management on all kinds of public lands to offset that which is going under asphalt and concrete."

Active wildlife management programs at Corps lakes in the southeastern States are administered by the Game and Fish Departments of the respective States. A total of 73,000 acres of project land and water are currently under license to these States for wildlife management.

Exemplifying this joint Federal-State management approach is that part of the Clark Hill Wildlife Management Area on the Georgia-South Carolina border maintained by the Georgia Game and Fish Division. This management area consists of approximately 20,000 acres of forest land on the shores of Clark Hill Lake. The pine ridges and hardwood hillsides provide for good wildlife production. The thinning of pine stands conducted by the Corps combined with prescribed burning by the State of Georgia have produced optimum wildlife benefits. An extensive series of planted wildlife openings has been developed to produce a more diverse wildlife habitat in this forest setting.

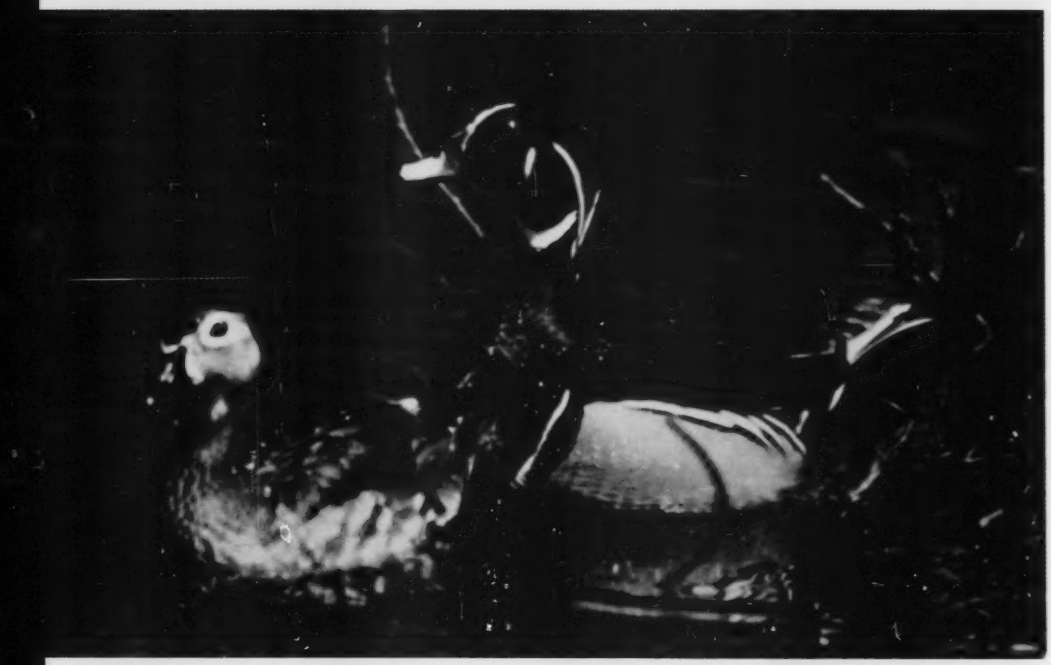
This management area, while well noted for its deer production, also is reported to have the best wild turkey population of any Georgia management area. Hubert Handy of the Georgia Game and Fish Division recently stated, "The Clark Hill turkey flock is used for restocking purposes. We trap some of them each year and scatter them around at other locations in the state." Gray squirrels, together with many non-game species such as woodland birds and small mammals, are also numerous. The State of South Carolina also maintains an active wildlife management program on its 13,000 acres of land at Clark Hill Lake. The Corps complements the State management programs at Clark Hill Lake by using beaver ponds to create new waterfowl habitats. Unaware they had been recruited to help increase the waterfowl population, confused beavers watched the water keep running out of their ponds this past summer. The Corps had deliberately breached several existing beaver dams on this 155,000-acre project.

A three-log drain covered with tin was placed in each breach extending beyond the dam limits. This permitted removal of the water behind the dam. The beavers, however, became extremely frustrated when they discovered that the water in their pond would not rise, even after they carefully filled in the breached section of a dam. Each drained beaver pond was seeded with Japanese millet and allowed to mature before the three-log drain was removed. The beavers were extremely pleased when they could once again repair a breach and watch the water level rise behind their dams. Had

Left—Dense stand of pine trees eventually creates a "biological desert" and wildfire hazard for wildlife. Thinning, followed by prescribed burning, improves the wildlife habitat.

Center—Waterfowl managers at Clark Hill started a wood duck population by attaching nesting boxes to dead trees.

Bottom—Clark Hill is reputed to have the best wild turkey population of any Georgia wildlife management area.



Left—Migrating ducks spy new waterfowl management area at Clark Hill Lake.

Left, below—Wary buck stands alert in midst of browse produced by forest management program.

A trio of wood ibis, America's only members of the stork family, venture close to picnic tables at Lake Ocklawaha, Fla.

they been overly observant, the beavers also may have noticed the unusual increase in the number of ducks that were keeping them company in this new waterfowl habitat.

The use of beaver ponds to improve waterfowl habitats is just one of a number of wildlife management activities being implemented by the Corps on Clark Hill Lake. The major effort to increase wildlife populations is an active forest management program. Nature develops dense stands of pine trees in this section of the country which, if left to mature, create a "biological desert." Wildlife is unable to sustain itself in a dense, mature pine forest. The shortage of sunlight and the thick layers of needles on the ground prevent the growth of hardwood trees and other low growing vegetation essential for wildlife.

In a thick pine forest, the trees must compete for space, sunlight, moisture, and nutrients. As a result, entire stands may be retarded and become more susceptible to attacks by insects and diseases. In order to provide the food and cover essential for wildlife, a forest management program was undertaken consisting of thinning dense pine stands, then conducting prescribed burns after removal and sale of the timber.

During the tree selection process, favorable consideration is given to mast-producing hardwood and retention of all den trees. Mature pine trees containing suspected nesting sites of the red-cockaded woodpecker, one of the endangered species protected at this lake, are also excluded from thinning operations. Small areas are cleared at strategic locations, creating openings inducive to improving wildlife habitat. The burns that follow reduce the wildfire hazard and enhance production of food plants for turkey, quail and deer.

A management program for improvement of small game has also been initiated at Clark Hill Lake. David Brady, the Corps wildlife specialist at this lake, believes that the small game hunter is the "silent majority" of the sportsman's world, and has begun managing his project lands in a manner that will increase the small game population among many well-scattered areas around the lake, ranging in size from 1/2 acre to 40 acres. Borrow pits, power line easements, fire breaks, former agricultural fields, and areas cleared of timber have been planted with the type of cover that can improve small game habitats.

Big game, such as deer and wild turkey, also benefit to some degree. Plants such as ceresa lespedeza, clover, dwarf sorghum, browntop millet, wheat and rye are planted in these wildlife food plots along with chufa, an "ice cream" plant for wild turkey. Crops raised on the larger fields are combined by local farmers on a share basis, making seed available for the next year's planting. This past fall, a successful dove hunting season was managed by the Corps on such a 40-acre field which was also used for the production of next year's seed grain.

A new waterfowl management area engineered by the Soil Conservation Service has been completed in the backwater area of Clark Hill Lake. This project consists of 20 acres of diked-in fields and a 10-acre impoundment used to supply

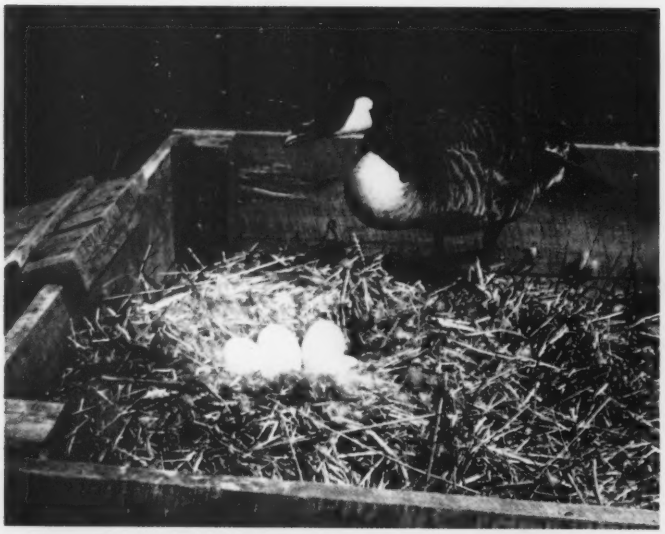
water to flood them. Corn, Japanese millet, and browntop millet were planted in the diked-in fields, which were flooded by releasing water from the impoundment prior to duck migration late last fall. Oak trees left within the diked-in fields produced acorns for ducks fortunate enough to use this area during the winter season. Attaching nesting boxes to dead trees produced an initial population of wood ducks. This new area, which attracted hundreds of ducks this past fall and winter, will be turned over to the Georgia Game and Fish Division for management, as well as other waterfowl management areas being planned for Clark Hill Lake.

The Virginia Commission of Game and Inland Fisheries and the North Carolina Wildlife Resources Commission divide the game and waterfowl management at the 48,900 acre John H. Kerr Reservoir on the North Carolina-Virginia border. Food plots are combined with a forest habitat improvement program to increase wildlife populations. Open fields planted with seed grains provide the setting for excellent dove populations. Since the pine forest on this reservoir had been severely infected by the southern pine beetle during the past summer, hundreds of acres of pine trees were cut by the Corps in an effort to control the beetle's spread. Wildlife may benefit from this adversity, however, as many of the areas where the dead and infected trees have been removed will be cultivated and converted to wildlife food plots.

The Mississippi Game and Fish Commission manages 5,000 acres of land at Okatibbee Lake in central Mississippi for habitat improvement of deer, squirrel, turkey, rabbit, quail, dove and various migratory waterfowl. The Alabama Department of Conservation maintains an active wildlife management program at several locations on the Black Warrior and Tombigbee Lakes in western Alabama.

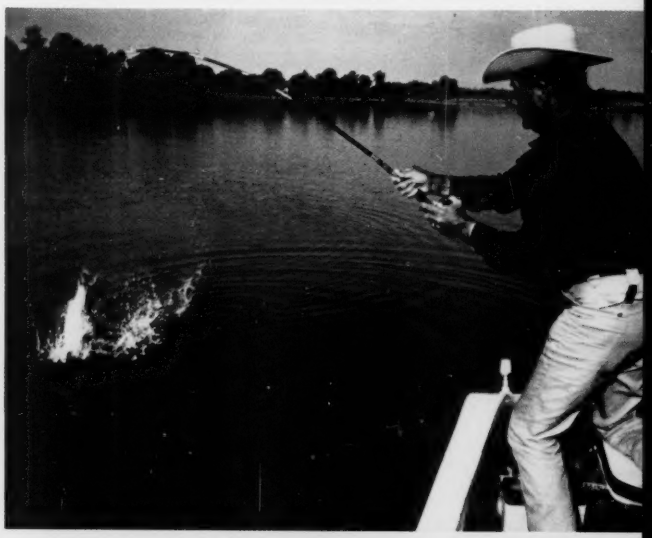
The Florida Game and Fresh Water Fish Commission is active in the management of the Apalachee Game Manage-

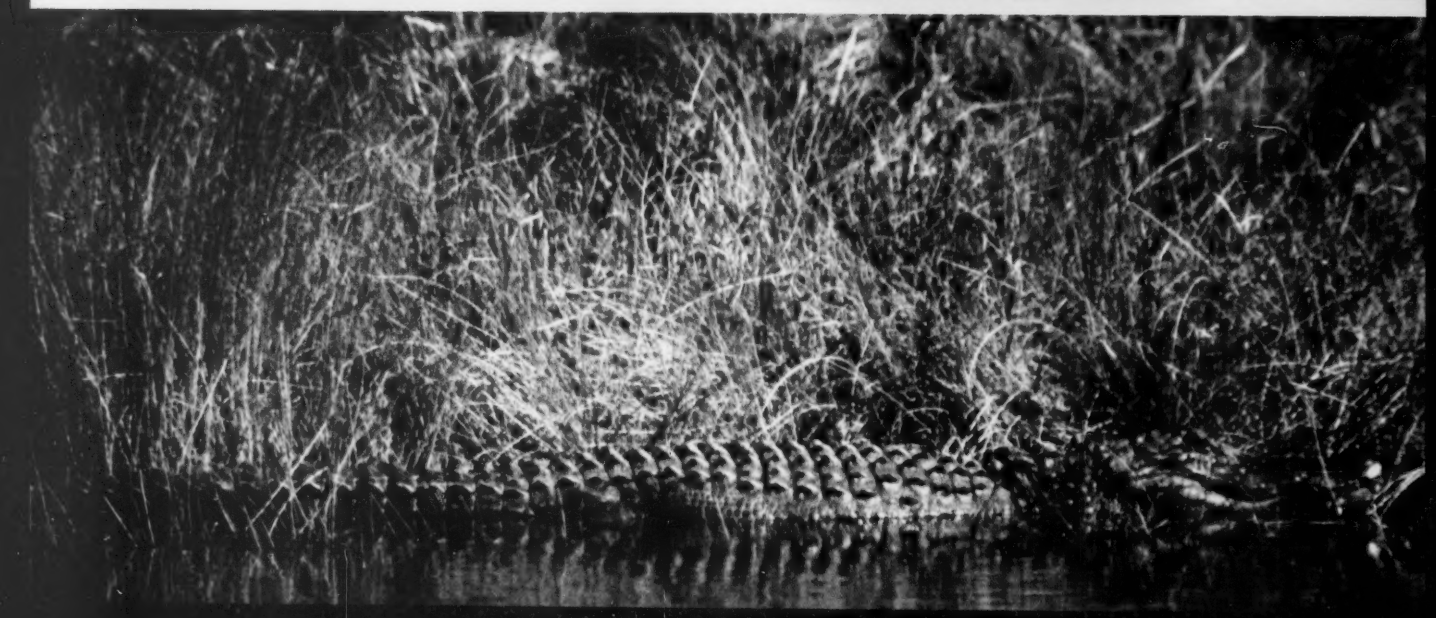
Corps works at keeping Walter F. George Lake waters from flooding spring nests, such as this one being guarded by Canada goose in Eufala National Wildlife Refuge.



Below—A bass strike at Walter F. George Lake.

Bottom—Perhaps aware of its endangered species status, an American alligator relaxes in the sunshine on the shore of Lake Seminole.





ment Area of Lake Seminole, a shallow lake located on the Georgia-Florida border. The hunting pressure on public lands is dramatically documented by the growth in numbers of recorded hunters using this 5,100-acre management area. This growth has tripled from 109,000 in 1965 to over 300,000 hunters in 1972. Because of the tremendous increase in hunting, some game species — such as the wild turkey — are no longer available for hunting. Still hunted, however, are deer, quail, dove, squirrel, snipe, and woodcock.

The wildlife management effort at Lake Seminole is now directed towards maintaining substantial quail and dove populations. Pine stands too thick for prime wildlife habitat are selectively thinned by the Corps, and prescribed burning is conducted by the State of Florida. These actions yield a healthy undergrowth of grasses and weeds which provide quail food and cover in the pine forest. In addition, 700 acres of the Apalachee management area are planted on a cooperative basis with local farmers, who leave the State of Florida's share of the crops in the fields for dove and quail food.

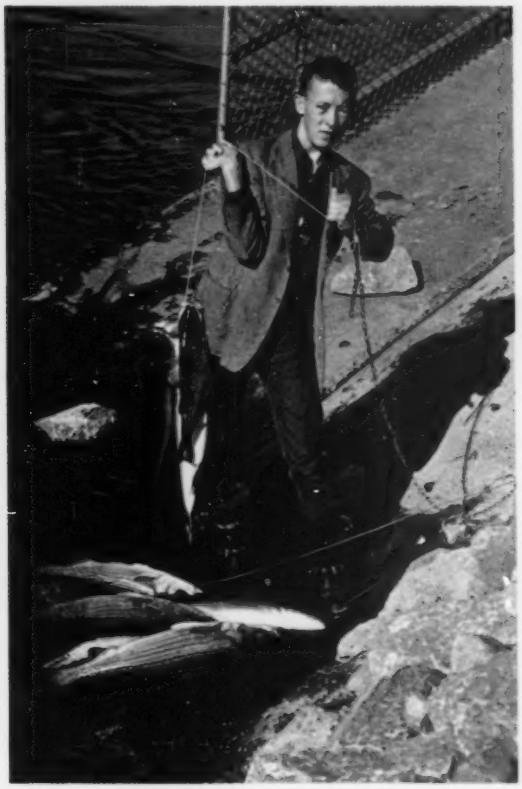
The U.S. Fish and Wildlife Service manages the Eufala National Wildlife Refuge located at Walter F. George Lake on the Georgia-Alabama border. This refuge, located at the junction of the Atlantic and Mississippi flyways, is considered one of the "Holiday Inns" used by the migratory waterfowl during the winter months, when approximately 30,000 ducks live at this 11,000-acre refuge.

With that many mouths to feed, Jim Tisdale, refuge manager, and his staff are busy all summer growing food for their winter visitors. Areas within the wildlife refuge are diked off and pumps dewater the land behind, so it can be farmed to provide winter waterfowl food. Twelve hundred acres of land are planted on a cooperative basis with local farmers, who leave 300 acres of corn and millet in the field. Prior to commencement of the fall waterfowl migration, the water is pumped from the lake to flood the fields of corn and millet. Natural food production in the marsh areas of the refuge supplements the field crops grown for waterfowl.

Near the end of last November, Tisdale stated, "The tables out on the refuge are set and we're just waiting on the ducks. Within the last week, we've picked up a bunch of birds. At least 10,000 or 15,000 are out there." There is little doubt that duck hunting in the general vicinity of central Alabama and Georgia has become substantially better with the establishment of this refuge on Walter F. George Lake.

Limpkins, one of Florida's rare species of wading birds, search for snail dinner at Lake Ocklawaha.

Snowy egret (opposite page) looks for lunch and American egret (left) wings its way past a patch of water hyacinth on Florida's Lake Seminole.



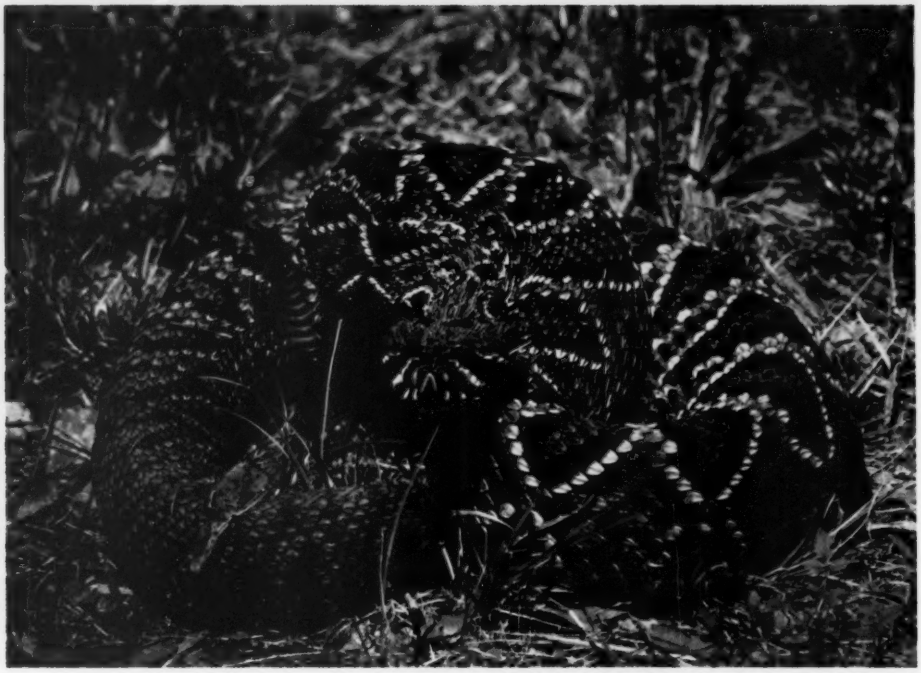
Meanwhile, a string of fishermen lines bank below Lake Seminole with results such as the striped bass proudly displayed at right.

The Canada geese on the Eufala refuge have had their own conservation of energy program in effect for many years — they no longer migrate north in the spring. About 6 years ago, a small flock of young Canada geese were brought to the refuge, had their wings clipped — so they could not fly — and were taught that the refuge was their home. Today this small flock has enlarged to over 200 completely wild and free flying birds that remain at Eufala to raise their young. These geese nest at various places around the lake, and the Corps attempts to control the lake level during the spring nesting period to prevent flooding their nests. During the summer bass fishermen are often surprised, but pleased, to see a flight of Canada geese pass over and land nearby on the lake.

Duck hunting is limited to a managed section on the Georgia side of the Eufala refuge, where a quality duck hunting experience is available for those hunters whose names are drawn from a pot. Those hunters winning the draw are permitted to use the limited number of blinds provided in this hunting area. A test program was initiated by the U.S. Fish and Wildlife Service during the past hunting season as part of an effort to eliminate lead shot, which causes lead poisoning of many waterfowl annually. All hunters were required to fire steel shot.

The Alabama side of the refuge is used for a conservation education program. An auto route, nature trail and overlook are provided for tour groups from elementary schools, high schools and colleges so that waterfowl and wildlife species such as deer can be observed in their natural habitat. Tisdale observed, "I hope we will be able to continue a hunting season, but I can see the refuge going more and more towards the conservation-education side. We have four or five school groups a week out here for tours."

Lake Ocklawaha, a Corps lake located on the completed part of the Cross-Florida Barge Canal in northeast Florida, furnishes habitats for many aquatic wildlife species not found in other States. In this subtropical setting, one may enjoy a picnic lunch while watching the wood ibis wading among the nearby water hyacinths. This long-legged wading bird is the only member of the stork family found in the



Closely eyeing the intruding photographer, this eastern diamondback belongs to the natural habitat maintained at southern wildlife management areas.

United States. The familiar legend that the stork brings the new baby into the home arises from the loving care which the stork gives to its own young. A shallow 13,000-acre lake, Ocklawaha is on the Atlantic flyway and serves as the winter range for huge populations of ducks. The lake also serves as home for a large population of limpkin, one of Florida's rare species of wading birds, as a result of the lake's tremendous increase in production of snails, the main diet of the limpkin.

One may observe an osprey hover over the water, set its wings and dive feet first, hitting the water with a great splash and emerging with a fish for its lunch as it returns to its nest in the top of a dead palm tree. Lake Ocklawaha supplies the essential environment for many endangered species that can be observed while enjoying a leisurely boat ride in this subtropical setting. In addition to those mentioned, the lake offers a habitat for the Florida manatee (sea cow), the southern bald eagle, American alligator, and the Florida everglade kite.

The Corps also manages lakes in this section of the country to increase production of fish. Lake levels are regulated each spring to aid in the spawning of bass and crappie. Since both fish begin fanning out their nests when the water temperature reaches approximately 65°F, the temperature is taken daily as soon as the water reaches 60°F. The fish spawn shortly after the water reaches 70°F. If at all possible, the lake levels are not lowered more than 6 inches from the time the temperature first reaches 65°F until 3 weeks after the water temperature first reaches 70°F. Regular reservoir operation is resumed as soon as the bass and crappie spawning has been completed.

At John H. Kerr Reservoir on the North Carolina-Virginia border, water releases are maintained throughout the striped bass spawning season in order to float the eggs until they hatch. This popular salt water game fish ascends to fresh water rivers each spring to spawn, and the fertilized eggs must drift in a current of clean water for several days before hatching.

A similar purpose is served by the locks on the Cape Fear River navigation project on the east coast of North Carolina during the spawning season of the American shad. This anadromous salt water fish goes up fresh water streams to spawn, but the construction of locks and dams on the Cape Fear River prevented this annual migration until the U.S. Bureau of Commercial Fisheries, the North Carolina Wildlife Resources Commission and the Corps jointly developed a procedure for locking the fish upstream during the spawning run in lieu of installing costly fishways.

The locking procedure consists of first opening the downstream gates of the lock chamber, followed by opening the four valves in each of the upstream gates to allow a low velocity flow of water through the lock chamber. The lock is left in this position for approximately 1 hour to permit the shad to enter. Then the upstream gate valves and the downstream gates are closed, after which the lock is filled even with the upstream water level. The upstream gates are now opened and then the valves in the downstream gates are opened slightly to create a current, so the shad will move out of the lock and proceed upstream to their former spawning grounds. This locking cycle is repeated many times during the American shad spawning season.

Noted conservationist Aldo Leopold, in his book, *A Sand County Almanac,* observes: "To sum it up, wildlife once fed us and shaped our culture. It still yields us pleasure for leisure hours." To insure posterity the same enjoyment of wildlife, we must continue and expand the cooperative wildlife programs, both consumptive and nonconsumptive, presently being pursued." Naturalist William Bartram endorsed this edict in his book: "This world, as a glorious apartment of the boundless palace of the sovereign Creator, is furnished with an infinite variety of animated scenes inexpressibly beautiful and pleasing, equally free to the inspection and enjoyment of all His creatures."

The legacy of wildlife is our challenge. The legacy of De Soto's journey must be passed on to future generations. ■

GROUND WATER

by M. S. Bedinger
Hydrologist, U.S. Geological Survey

Alluvial aquifers along water courses (such as Fountain Creek in Colorado) are among most prolific suppliers of irrigation water for nearby valley lands. D. L. Bingham

Though they represent nearly 20 times the combined volume of our rivers, lakes and reservoirs, our largest sources of potable water are little known to us and virtually undeveloped. In terms of storage volume, there is enough ground water in our aquifers to supply this Nation's needs for several centuries at current rates of withdrawal, but not without accompanying development problems.

We are talking about a volume that Nace[1] estimates at about 180 billion acre-feet (or 222 x 10^{12} cubic meters) of potable water that lies within a few thousand feet of the American land surface. At the present time only about 20 percent of our withdrawals for uses other than hydropower generation comes from ground water (figure 1). Obviously, aquifers are capable of playing a greatly enlarged role in our national water economy, but the extent of that role will depend on two things. First, we must broaden our knowledge; second, we must expand the application of scientific principles in developing and managing our ground water resources.

Ground water management, in the broadest sense, is any planned action that affects ground water. It may include actions that develop ground water as a source of supply, dispose of waste liquids or solids on the surface or underground, affect the earth's surface (such as agriculture, urbanization, strip mining) and actions that control or divert water (such as levees, revetments, canals, and dredging).

The effect of management actions on water at the land surface is often obvious and easily foreseen. The effect on ground water is generally not obvious and may not be detected until problems develop. The purpose of this article is to describe the role of ground water as an integral part of the overall water resource of the Nation, to describe the relations between environmental stress and ground water response, to describe the methods of scientific ground water management, and to illustrate the relation between ground water and environmental stress by a few case histories.

The Hydrologic Cycle

The hydrologic cycle is the term used to describe the continuous movement of water as ice, vapor, and liquid in the atmosphere, in snow fields, glaciers, lakes, streams, oceans, and underground. All usable water in the hydrologic cycle is in continuous movement from one environment or state to another. A diagrammatic representation of the hydrologic cycle is shown in figure 2.

Movement of water beneath the land surface is a vital part of the hydrologic cycle. A part of the water that falls as precipitation moves into aquifers by downward percolation of rain water or snow melt. The part of precipitation that becomes ground water varies from a fraction of an inch to 2 feet or more per year. The variation is due to differences in a number of factors, such as permeability of material above the zone of saturation, evapotranspiration, and depth to ground water below land surface.

Man modifies the ground water part of the hydrologic cycle in many ways — some intentional, others unintentional. Ground water changes are produced by such diverse actions as damming streams to detain flowing water and provide storage for use during dry periods, cloud seeding and weather modification, constructing locks and dams for navigation, diverting water by canals and pipelines, withdrawing ground water by wells for various uses, and recharging water underground to store wastes or salvage surplus water.

Response to Stress

Stresses on an aquifer, both natural and man induced, can be classified as hydraulic, thermal, and chemical. The response to any given stress will be in accordance with the laws of conservation of energy and mass. The equation of continuity, *inflow — outflow = change in storage,* is a means of stating the mass balance equation when considering the hydraulic stress and response in the system. Similar equations could be expressed regarding the thermal and chemical balance in the aquifer.

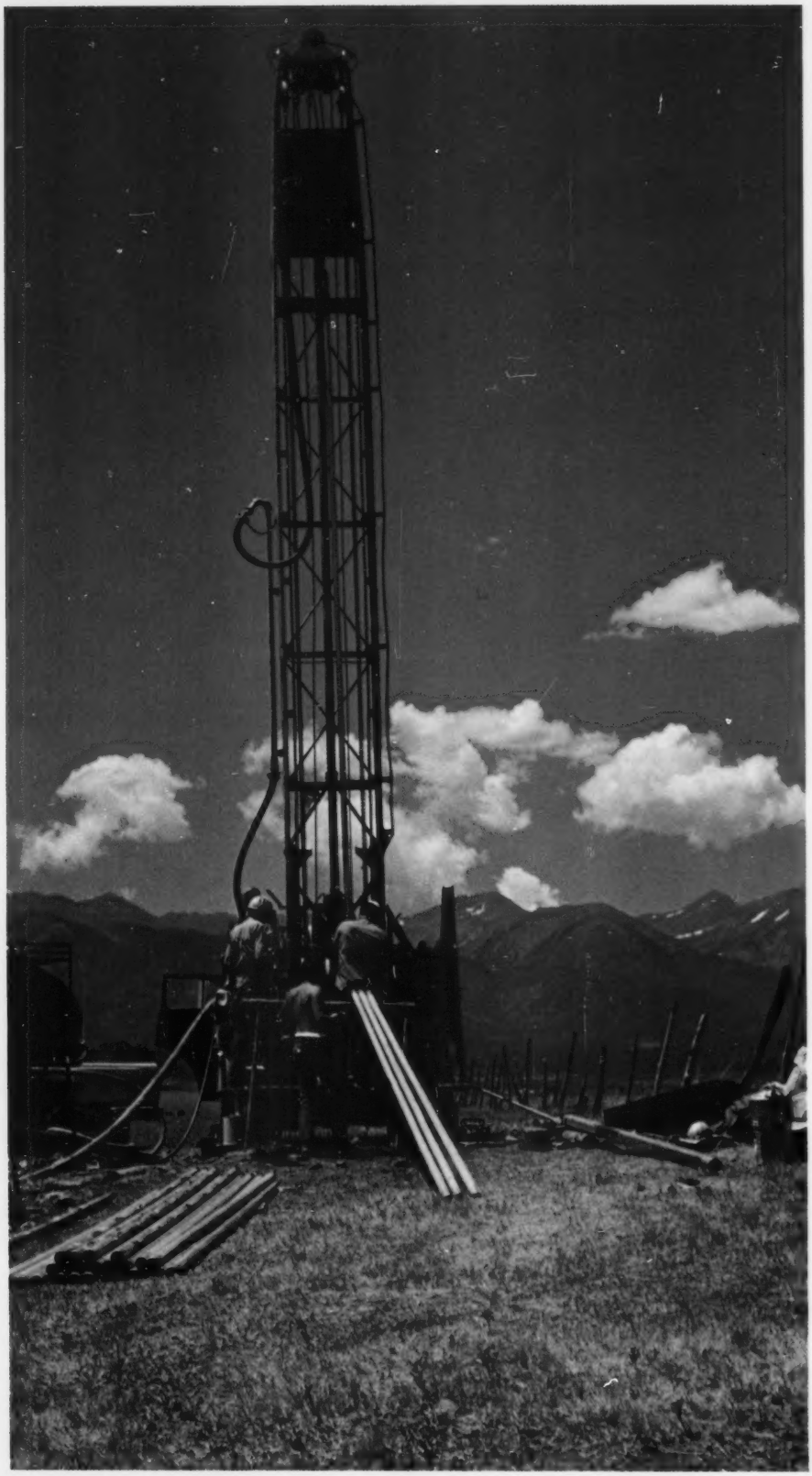
Under natural conditions, a state of balance is reached over a long period among the hydraulic, thermal, and geochemical stresses in the flow system. Any new stress imposed on the system — whether hydraulic, thermal, or chemical — may upset the natural balance of all three factors. In addition, the framework of the system — that is the physical, chemical, and thermal properties of the system itself — may be modified. If the newly imposed stress is maintained long enough, a new equilibrium will be reached.

The rationale for response to changes in stress may be stated as follows: (1) the flow system reacts to each stress in accordance with the laws of conservation of energy and mass; (2) any given stress or combination of stresses on the flow system may result in a trifold response — hydraulic, thermal, and chemical; (3) the system response is uniquely dependent upon the geometry and the physical and chemical characteristics of the system.

Predicting Aquifer Response

The hydraulic response of a specific ground water system to pumping stresses depends upon the reservoir parameters (transmissivity and storage coefficients), hydrologic and geologic "boundary conditions," and the positioning of withdrawal developments within that system. In ground water hydrology, the expression "boundary conditions" refers to the lithologic, geochemical, and hydraulic conditions at the boundaries of a ground water reservoir. They could be the presence of surface streams or reservoirs, the position of salt water at a certain depth in the aquifer, or the location of impermeable rock strata. These bounding conditions are the primary factors influencing the functioning of a hydrologic unit and its response to development.

[1]Nace, R. L., "Water Management, Agriculture, and Ground-Water Supplies," Circular 415 (U.S. Geological Survey, 1960), p. 3.



Drilling rig tests depth and structure of deep basin deposits underlying this mountain-bordered western valley.

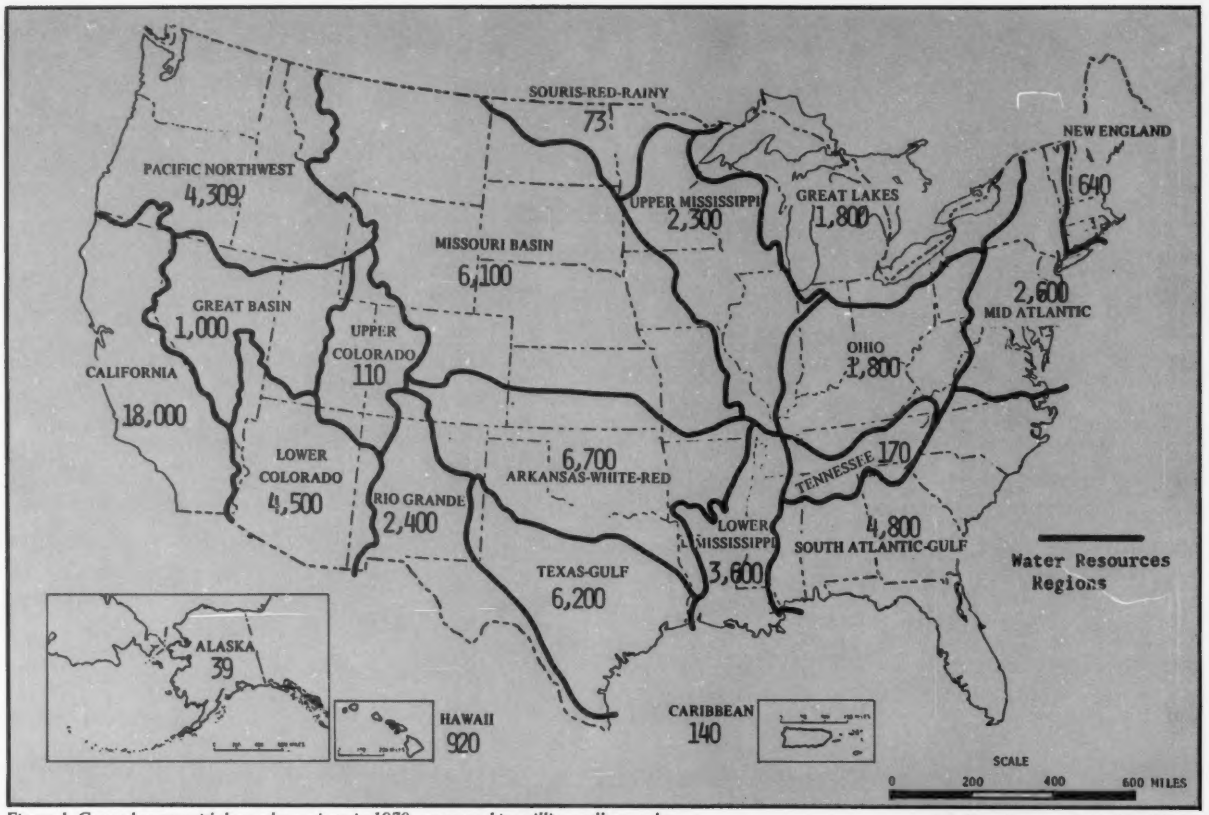
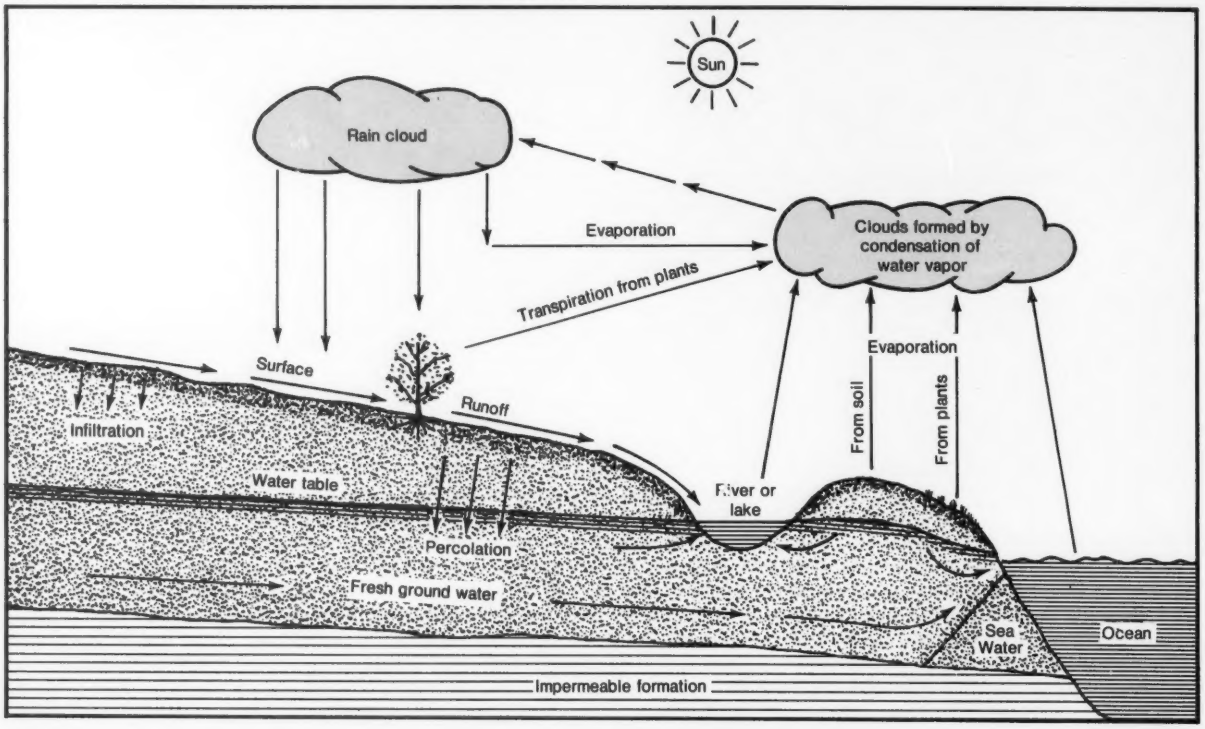


Figure 1. Ground water withdrawn by regions in 1970, measured in million gallons a day. U.S. Water Resources Council Bulletin 16

Figure 2. The hydrologic cycle describes the continuous movement of water.



Hydrologist measures irrigation well discharge.
J. E. Moore

The flow of ground water and water-level declines can be described and analyzed mathematically using partial differential equations, provided that adequate hydrologic and geologic information is given. These equations and the concepts on which they are based are well accepted by hydrologists and others dealing with the flow of fluids through porous media. Such mathematical analysis has been used to determine the effects on ground water of impoundments on the McClellan-Kerr Waterway of the Arkansas and Verdigris Rivers in Arkansas and Oklahoma, for example, and for countless predictions of well-field yields in all 50 states.

Computer methods provide solutions for the equations of flow for complex field problems, and thereby provide means for simulating the operation and response of very complicated systems. The advent in recent years of high speed, large capacity digital computers has increased the capability to solve flow equations by digital methods, and digital computers now play a major role in ground water analysis.

Ground water models for analysis and management of water quality and heat flow are in comparatively early stages of development. Efforts currently underway include: modeling and predicting the movement of the salt-water/freshwater interface near Brunswick, Ga., and Miami, Fla.; recharging water of differing quality into an aquifer and predicting the resultant quality changes near Lubbock, Tex.; predicting quality changes in the ground water reservoir due to changing irrigation practices near Pueblo, Colo.; and prediction of chemical and physical effects of subsurface disposal of liquid and solid wastes in several locations in Florida.

Water quality models — most commonly mathematical — seek to simulate ground water quality conditions in order to comprehend them and to predict the chemical effects of changes in integrated knowledge of the rock-air-water geochemical associations, the flow system, biology, and other elements of the gross system that influence water quality.

Models range in scope from those concerned with specific chemical reactions between a single fluid and mineral to comprehensive "salt balance" and "mass transport" assessments which may attempt to account for the receipt, modification, and discharge of the total mineral-salt load moving through a ground water basin. Models may also be used to predict the effects of manmade development on water quality.

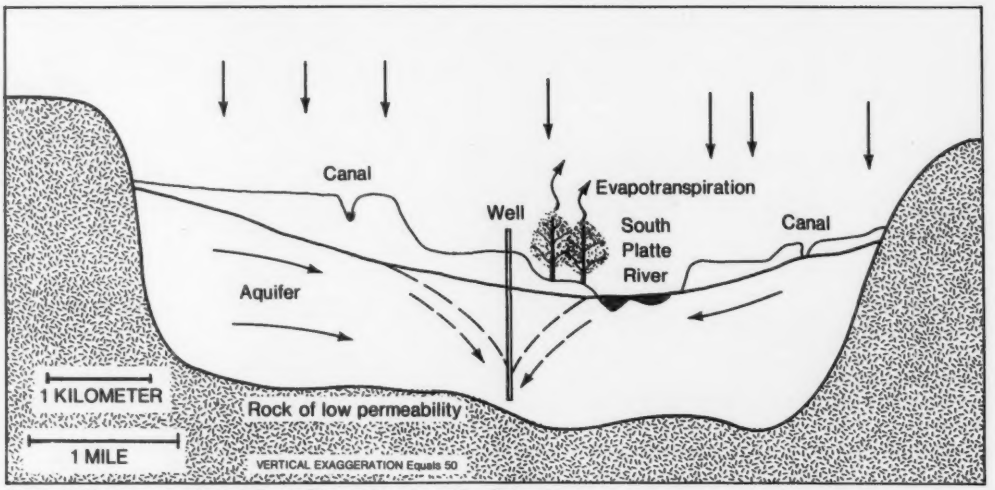
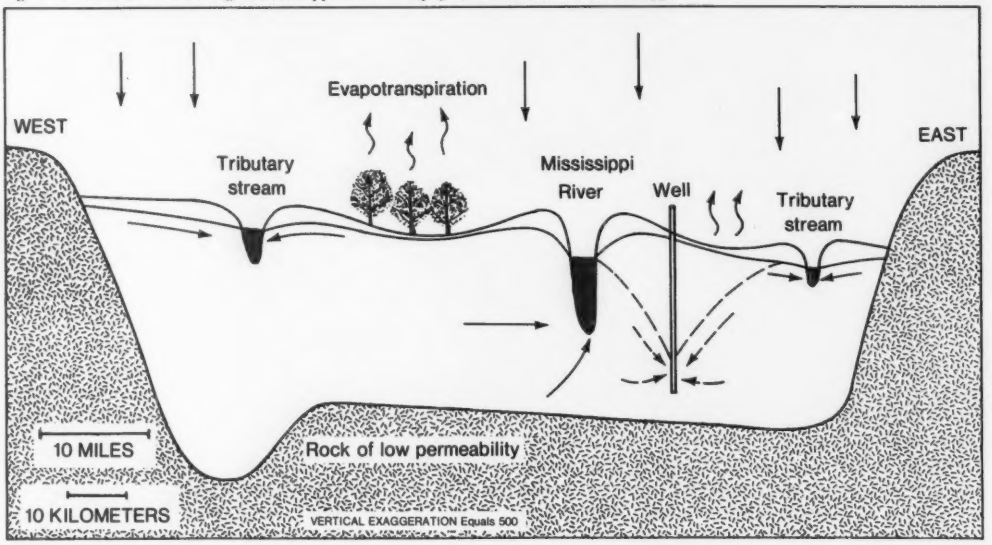


Figure 3. Cross section through South Platte alluvial aquifer, Colorado.

Figure 4. Cross section through Mississippi alluvial aquifer, Arkansas and Mississippi.



Ground Water Management

Three general types of ground water systems are discussed here: (1) alluvial aquifers associated with perennial streams and their adjoining and underlying water-saturated deposits, (2) sand and gravel aquifers — including the productive aquifers in the Coastal Plain, High Plains and western valleys, and (3) consolidated rock aquifers — of which sandstone, limestone and basalt are the most important. The response to ground water withdrawal will depend upon that aquifer's specific properties, in addition to the nature and amount of recharge to the aquifer, and the nature and amount of discharge by both evapotranspiration and baseflow to streams. The effects of ground water development in selected aquifers are discussed in the following paragraphs with regard to natural conditions and aquifer response to selected man-induced stresses.

Alluvial aquifers along perennial water courses are among the most prolific in the country. These aquifers are generally composed of alluvial sand and gravel, and commonly lie in valleys cut through less permeable rock. Ground water in the aquifer is hydraulically connected with the associated stream and lies at shallow depths, commonly within reach of plant roots. Since the alluvial material above the sand and gravel aquifer may range from fine sand to silt and clay, the water in the aquifer may be under either semi-confined or water table conditions.

Operation of the flow system in the perennial stream's alluvial aquifer system depends largely on the climate and extent of the aquifer. Consider first an alluvial aquifer in a semiarid environment such as in the South Platte River Valley of Colorado (figure 3). Rainfall is low, 14 inches (36 centimeters) or less, and is exceeded by the potential evapotranspiration. Thus, the alluvial valley is intensively irrigated by surface water diverted from the South Platte River and ground water withdrawn by wells. The relatively narrow aquifer, only 2 to 10 miles (3 to 16 kilometers) wide, averages 65 feet (20 meters) in thickness. Therefore, the amount of water in storage is relatively small, on the order of only 10 or 20 times the annual withdrawal.

Progressive series of closeups shows telltale white strip formed by salt deposit due to evaporation from shallow water table under Colorado's South Platte River Valley. L. F. Konikow

Water demand is large compared to the streamflow. While water withdrawn during the pumping season can be taken largely from storage within the aquifer, the water withdrawn must be restored by streamflow depletion to sustain constant withdrawals year after year. Streamflow depletion includes both induced infiltration from the South Platte River and reduced ground water discharge to the river. Thus, the water supply is limited in quantity to input from the natural streamflow and those small quantities of water that can be salvaged from evapotranspiration losses of ground water by a lowering of the water level.

About 55 percent of the water applied as irrigation is evaporated and transpired by plants. The remaining 45 percent infiltrates into the ground and reaches the aquifer. Since this process concentrates the salts in solution in the aquifer and in the soil, continued reuse as the water moves down valley increases its salt content.

Operation of the flow system in the perennial stream and alluvial aquifer system in a water excess area is illustrated by the Mississippi River Valley in Arkansas and Mississippi (figure 4). Here the rainfall, about 50 inches (127 centimeters), annually exceeds potential evapotranspiration. The alluvial deposits, from 100 to 125 feet (30 to 38 meters) in thickness, extend beneath and several tens of miles away from the Mississippi River on each side. Thus, the amount of water in both storage and streamflow is large compared to the annual withdrawal.

Major withdrawals from ground water are for supplemental irrigation of row crops (such as cotton and soybeans) and for flood irrigation of rice, and therefore seasonal. Natural recharge of the aquifer is by infiltration of the precipitation; natural discharge is by evapotranspiration and seepage to the stream. In response to these withdrawals, the water levels are lowered, thereby reducing losses through evapotranspiration or seepage to the Mississippi River and its tributaries on the alluvial plain. In fact, drawdown near the streams may induce recharge from the streams to the aquifers. Thus, ground water management can "salvage" ground water by reducing

OVERALL WATER-BUDGET ANALYSIS

Inflow	MGD
1 Precipitation	1,600
Outflow	
2 Evapotranspiration of precipitation	760
3 Subsurface outflow of ground water	470
4 Streamflow discharging to salt water	340
5 Evapotranspiration of ground water	15
6 Spring flow	15
Subtotal (items 2–6)	1,600

MGD = Million gallons per day

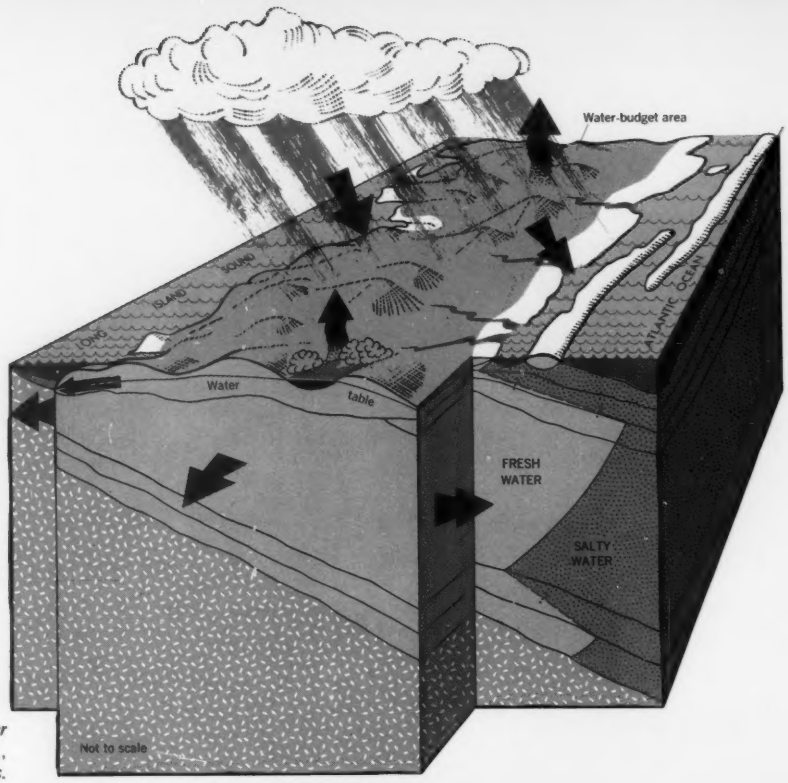


Figure 5. Major elements of fresh water inflow and outflow from Long Island, N.Y., under natural conditions.

losses from evapotranspiration and ground water flow to streams, making the water available for other uses. Water quality degradation by salt concentration is generally not a problem, because of the excess of through flow over demand.

Long Island is an example of a self contained flow system that is easy to understand. The island is 120 miles (193 kilometers) long, has a surface area of 1,400 square miles (3600 square kilometers) and is underlain by a thick wedge-shaped mass of sand, silt, clay, and lesser amounts of sand and gravel (figure 5). These deposits are capped by hills of soil and rock deposited at the terminus of glaciers during the Great Ice Age. The surficial glacial deposits are so permeable that over one-half of the 44 inches (112 centimeters) of average annual precipitation is able to percolate downward to the water table. The ground water reservoir beneath the island contains 10 to 20 trillion gallons (38 to 76 x 10^{12} liters) of fresh water.

As applied to Long Island, the equation of continuity indicates that the amount of fresh water that reaches the aquifer beneath Long Island in a given period of time is equal to the amount that leaves the island, plus or minus a change in the amount of fresh water in storage. The continual process of recharge by infiltration of precipitation and movement of the ground water by subsurface flow to the sea keeps out the sea water and keeps the water beneath the island fresh.

The major management question on Long Island is how much water is available for use without continually depleting the supply and without degrading the quality of the supply. It follows from the equation of continuity that if there is a net loss of fresh water recharge, then the mass of fresh water beneath the island will diminish and sea water will encroach. In other words, ground water management on Long Island is a question of selecting tradeoffs between withdrawal, artificial recharge, and sea water encroachment.

Sea water intrusion beneath the island first occurred in the early 1900s when ground water withdrawal lowered the head in the fresh water aquifer and disturbed the balance between fresh and sea water. By stopping or limiting pumping, and by using artificial means (such as injection wells and recharge pits) to recharge the aquifer, it was found that sea water intrusion could be reversed and the aquifer reclaimed by fresh water.

Although about 200 million gallons (757,000 cubic meters) of water per day are returned to the aquifer through cesspools, septic tanks, recharge wells, and leaky pipes, pumpage during the past decade (1961-70) has averaged 300 to 400 million gallons (1.1 to 1.5 million cubic meters) per day. In addition to this net loss, surface recharge to the aquifers has also been reduced by the construction of impermeable surfaces — namely streets, buildings, and parking lots.

It can be seen that present ground water management methods diminish net recharge to the aquifers and allow some sea water intrusion. If an alternative management decision is made to avoid this continued depletion of Long Island's fresh ground-water resources, then we must ultimately reach a stage of development where total fresh water inflow equals total fresh water outflow, either through decreased pumping or increased recharge.

These examples indicate that development of ground water resources requires as much knowledge of the total system and the capability to predict the effect of changing stress upon that system as the development of surface water resources. More important is the evolving realization that our Nation's aquifers are tomorrow's source of supply; yet we know much less about them than our surface water flows.

Photographer reaches for his underwater camera and strobe light.

by Gilbert L. Chase

DIVING FOR EIS

Dredging to improve and maintain navigable harbors and waterways had long been among the authorized responsibilities of the Corps of Engineers when the National Environmental Policy Act (NEPA) of 1969 became Federal law. Unfortunately, acceptance of the NEPA concept did not automatically produce useful environmental impact statements (EIS). The lack of essential environmental knowledge soon made the New England Division (NED) aware that it needed some means of actively studying the ecological consequences of disturbing underwater habitats.

With over 230 navigation maintenance projects and dredging studies scattered over 4,350 miles of New England coastline, the task of compiling the necessary information seemed insurmountable. Factual data with regard to water quality, biota, sediment type and physical characteristics are still virtually nonexistent for many of these projects and until 1967 there was no research on the effects of dredged material disposal within specific ocean areas. Furthermore, regulatory agencies responsible for reviewing impact statements often raised more questions than they supplied factual input.

There is still a lack of knowledge at all levels on what an EIS is, its functions and what procedures are to be followed. A backlog of projects with a need for either impact assessments or more formal statements exists and, while it is our intention to reduce this load, the process will be painfully slow.

In March 1972 NED decided to develop its own inhouse capability to conduct on-site reviews in order to acquire the necessary data for adequate impact statements. As a result, the division's Environmental Analysis Branch activated a three-man diving team to perform biological sampling and underwater photographic documentation of coastal navigation and ocean disposal areas. In many instances, SCUBA (self-contained underwater breathing apparatus) diving surveys can obtain environmental data much more rapidly and efficiently than conventional dredge and grab sampling gear. Sampling by a diver is often the only possible way to investigate biological communities associated with ledges or rocks, since the hard substrate prevents penetration by the conventional shipboard sampling techniques. The fact that benthic organisms are not uniformly distributed means that dredge or grab samples produce a biased view of the true diversity or population numbers. A biologist-diver, on the other hand, can overcome this sampling bias by direct observation of a relatively large representative area and record the degree of uniformity or patchiness. In the case of small demersal fish and mobile crustaceans — such as lobsters and crabs — a diver's observations are usually more effective than mechanical sampling.

The observed data is incorporated directly into appropriate sections of an impact statement as prerequisite information for making more reliable assessments and for predicting real and probable impacts as well as feasible alternatives in subsequent sections of that same EIS. Should the need later arise, these preoperation surveys also provide a basis for postproject comparison and facilitate knowledgeable responses to questions and comments posed by reviewing agencies.

Mr. Chase is a marine resources specialist in the Environmental Analysis Branch and division dive officer for the Corps' New England Division.

Underwater Techniques

The key factor in the success of any diving mission lies in its planning and coordination. Presurvey coordination is conducted with harbormasters and shellfish wardens who are knowledgeable about local water conditions. Diving team members require advance information on factors such as excessive turbidity, strong currents, heavy boat traffic and high sea states that may impair or preclude the team's photographic efforts as well as the diving operations. Team diving routines and safety must take into account the possibilities of such undesirable conditions.

The majority of these diving surveys are made in harbors or channels with water depths of 40 feet or less, using the "buddy system." For dives in excess of 60 feet, one team member is appointed diving supervisor and maintains a close watch on bottom time. All dives are scheduled to avoid the need for decompression, and computation of bottom time is of utmost importance.

The diving team generally operates from small boats, although open-ocean assignments may require a larger, more seaworthy vessel. When ocean stations are used, each one is marked with a surface buoy and anchor line which the divers can follow to descend and ascend. The buoy markers serve a dual purpose; they facilitate relocation of the stations and provide a point of safety orientation for the divers. Once on station, the diving boat may either anchor securely or drift clear of the marker buoys, in which case an inflatable rubber raft is deployed during actual diving operations as a precautionary standby and tracking safety measure.

The principal ecological survey technique employed by the diving team is underwater photography using waterproofed 35mm cameras and strobe lights. Compactness and versatility make this type of camera ideally suited to a diving program that requires random closeup vertical and oblique photographs taken at predetermined intervals along a given transect. The photos provide a permanent record for comparing postoperational findings in addition to documenting diver observations. A metal frame and tripod attachment is used to define a known bottom area. This allows quantification of invertebrate organisms that are either too small or too densely populated to be counted accurately by a diver.

The value of the photographic technique becomes apparent when combined with one of the numerous types of transect methods available to a diver for semiquantitative evaluation of underwater life. Circle-sweep or line transects are the most common. The circle-sweep method evaluates a plot of 12.5 square meters by attaching a 2-meter line to a cement weight or stake driven into the substrate. Using the stake or weight as a focal point, a diver swims in a circle with

Left—Diving team checks SCUBA gear before starting underwater mission to document ecological changes at an ocean dredged disposal site.

Below—Shipboard inspection and measurement of bottom samples help biologist divers determine status of marine life on station.

Bottom—Divers ready photographic equipment prior to underwater inspection of breakwater.

the rope extended and records the nature of the substrate, animal and plant life and other pertinent ecological information.

The line transect method consists of one diver in the team swimming along a 25-meter line while observing and counting all organisms encountered within a meter to either side. The results are more quantitative and representative of prevailing seafloor conditions because this method samples a greater area (50 square meters). Where depth or visibility is critical, this method may be performed by two divers swimming on either side of the line. Each transect is oriented on specific compass bearings in order to provide a more accurate location description. Vertical or sloping surfaces in rocky areas require quantification by means of a standard square meter or 0.25 square meter quadrat.

Every effort is made to accomplish as much as possible while underwater to eliminate as much time-consuming laboratory analysis as possible.

Sidecast Dredging Research

One of the first assignments, and a major factor in the establishment of our diving program, was the investigation of environmental effects caused by sidecast dredging. The proposed use of the sidecast dredge in New England waters precipitated considerable controversy among State and Federal environmental agencies. The objections presented were not without merit as the project areas selected for maintenance by this method are characterized by extremely strong tidal currents and many have adjoining shellfish beds.

These agencies feared that the high velocity currents associated with the proposed dredging operation sites would transport the disposed material back into the channels or inner harbors being dredged or cause the material to drift into valuable shellfish areas. It was the consensus of the regulatory agencies involved that turbudity and siltation from the sidecasting dredge operation would seriously disturb a much larger area than the conventional hydraulic or bucket methods of dredging, and that localized displacement of sediments might accelerate erosion processes and alter natural circulation patterns. The use of sidecast dredging during certain periods could also cause adverse effects upon fish migrations.

In consideration of these potential impacts on marine life and water quality, NED agreed to perform certain environmental tests proposed by the concerned groups. A modest study was outlined in an attempt to define the dredging operation in environmental terms and develop project-specific operational guidelines. Some operational safeguards that were implemented included:

- dredging only on out-going (ebbing) tides;
- casting in the direction of prevailing littoral drift;
- limiting the areas of operation to outer bars or shoals and coastal inlets;
- scheduling dredging action to circumvent peak periods of fish migration.

Preliminary diving observations made during actual dredging showed that several organisms were damaged or killed by this type of dredge. These organisms include amphipods, annelids, juvenile soft clams, starfish, cancer crabs, moon snails, and the sand launce. The latter is a fish species with the peculiar habit of burrowing into sandy areas and, therefore, extremely susceptible to this type of bottom suction dredging. All of these marine animals are inhabitants of the sand substrate that characterizes inlet channels and ocean shoals destined to become the objects of sidecast dredging. Fortunately, however, such high energy sand areas generally exhibit low numbers of benthic organisms; thus the biological effects of dredging are considered minimal.

In addition to the diving observations, aerial photographs have been obtained to delineate the discharge plume associated with sidecast dredging and the plume's duration. Water samples collected and analyzed revealed that the turbidity levels ranged from 2.4 to 9.4 Jackson Turbidity Units (JTU). However, a Secchi disc used to measure water transparency and SCUBA observations illustrated zero visibility in the immediate discharge splash zone until the large sand particles settled out after 2 to 5 minutes. Unfortunately, this settling phenomenon also distorts turbidity readings derived from spectrophotometer measurements. Therefore, in-situ measurements using a towed transmissometer system will be employed during this spring's scheduled dredging to verify the assumption that higher levels of turbidity occur for somewhat longer periods.

Diving surveys are also planned to determine the influence of dredging frequency on the stability of local biota and recolonization rates in the dredged area. Underwater photographs of the dredge's suction grate path will be included.

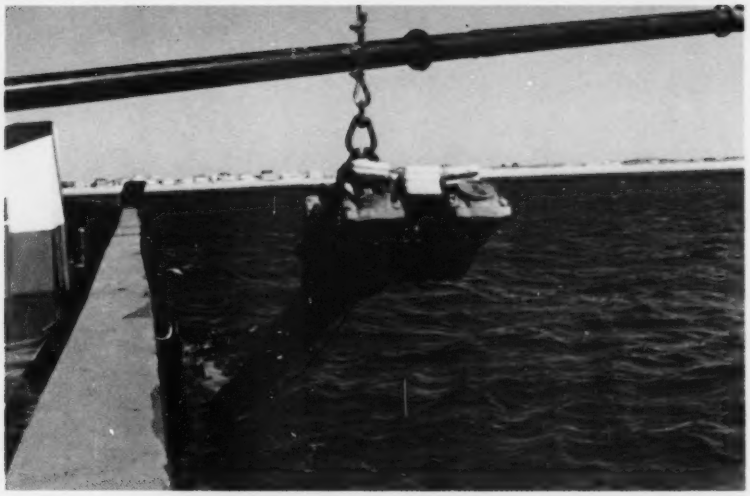
Interagency Diving Activities

Two occasions marked the first cooperative diving surveys undertaken by Federal agencies in the New England region in relation to ocean disposal. In June of 1974 biologist-divers from NED and the National Marine Fisheries Service at Woods Hole, Mass., completed a joint reconnaissance of a proposed ocean disposal area at Browns Ledge in Rhode Island Sound. This site analysis was prompted by the closure of the long-established Brenton Reef Dump grounds off Newport, R.I. Local fishing interests and conservation groups campaigned strongly against further dumping, necessitating the search for an alternate disposal area since Brenton Reef had been the only EPA interim dump site approved in the entire southern Massachusetts and Rhode Island region.

Browns Ledge is located approximately 10 miles southwest of Gay Head, Martha's Vineyard. A 1-nautical-square-mile area immediately south of the ledge was recommended for study by the respective Departments of Natural Resources of the State of Rhode Island and the Commonwealth of Massachusetts. Geographically and politically speaking, the proposed site is ideally located in that it lies well beyond the 3-mile limit of State territorial seas and also those waters protected under the Cape and Island Ocean Sanctuary Act. However, this location is also part of the southern New England fishing grounds which support commercial fleet operations for cod, yellow-tail flounder, lobster, ocean quahogs and a variety of industrial fish species.

A total of 13 dives were made at 10 stations in water depths ranging from 70 to 130 feet. Single "bounce dives" of 8 to 12 minutes' duration were performed at the deeper water stations. The dual objectives of these dives were to compile a photographic assessment of seafloor conditions and associated epibenthos and to identify any commercially important fishery resources or favorable habitat. The diving observations provided a data base for planning more detailed investigations and afforded an immediate appraisal of the suitability of the site for receipt of polluted dredge material.

Additional investigations by NED will eventually complete a comprehensive baseline research program that includes bathymetry profiles, chemical and physical analyses



Left—Effect on marine life of suction grate dragged along bottom during dredging operations is being researched by divers.

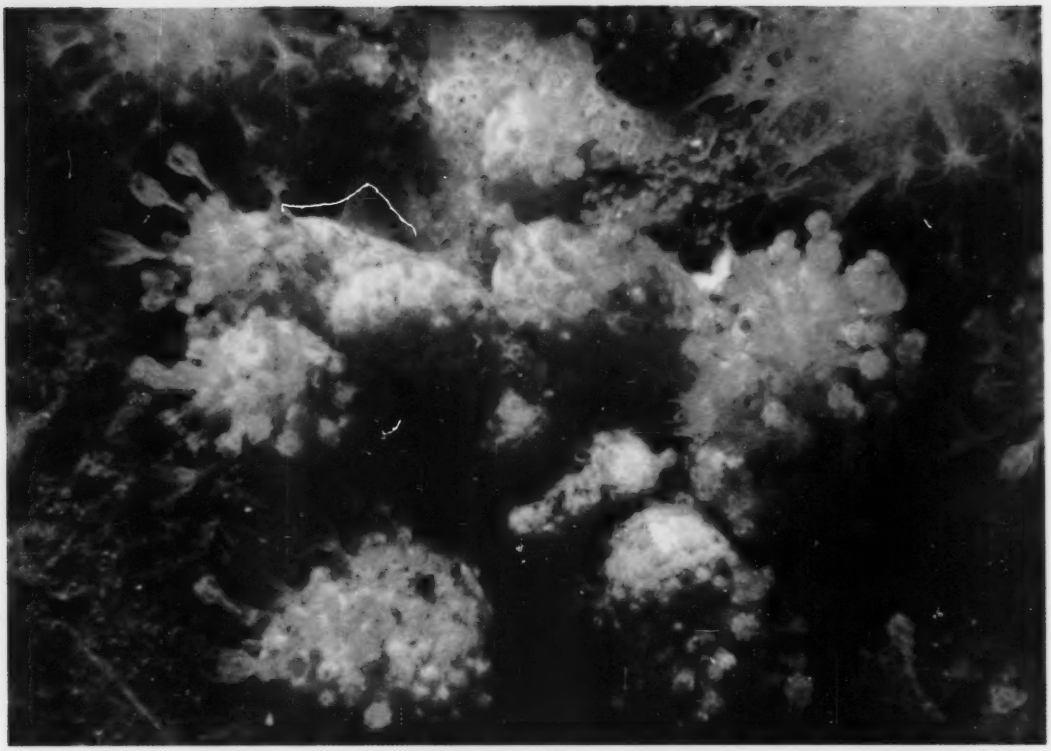
Center—Diver dons goggles just before team descent into Rhode Island Sound.

Bottom—Inflatable raft transports divers between support ship and dive station.

Sediment cloud produced by these cancer crabs on compacted silt-clay bottom photographically indicates presence of a soft, fine grained surface.

Juvenile starfish Asterias forbesi *among algae on breakwater structure. This species displays extreme variations in color.*

Eelpout and cunner swim among soft pink corals, hydroids and juvenile blood stars, all part of typical benthic community associated with glacial boulders and rocky bottom at Browns Ledge.



Colonies of soft corals, some with tentacles extended, photographed at 65 feet, Portsmouth Harbor, N.H.

of bottom sediments and biological dredge samples. A contract with the University of Rhode Island will continue to supply data collection on turbidity, current dynamics and benthic ecology through October 1975. These studies are designed specifically for the benefit of the EIS evaluation process rather than for use with the actual operations monitoring and regulating of any projects. Collectively, when fully interpreted and analyzed, this information will be compared with the new EPA ocean dumping criteria and guidelines.[1] Should the Browns Ledge site ultimately receive approval, postoperational photographic comparisons of the area will facilitate estimating the extent of the environmental alteration.

As development of a regional disposal site proceeds, the associated monitoring and research programs should be extended. Spot-check analyses of the receiving waters and biota must become a routine procedure if the interests of natural marine resources are to be properly safeguarded. Of extreme importance is the question: when does a dumping site, any site, reach a point of stress on the environment? In other words, what is the saturation or loading capacity of the ecosystem? These are questions for which research has yet to supply answers. That is why the in-situ observations and sampling capabilities of the diver must continue to supplement existing knowledge and provide new information relative to these unknowns.

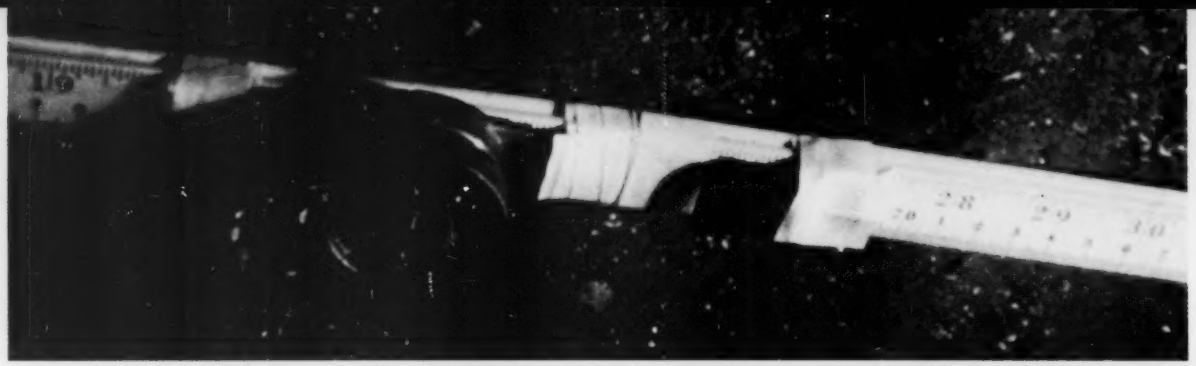
The second multiagency survey was made at the Brenton Reef Dump during a 4-day period in September 1974 with biologists from NED, the EPA National Marine Water Quality Laboratory at Narragansett, R.I., the National Marine Fisheries Service, and the University of Rhode Island. It was the first time that divers had made a direct examination of the underwater dredged material pile. The extreme patchiness of the sediments, topography and erratic faunal densities associated with disposal sites always presents difficulties in interpreting samples mechanically collected from surface vessels. This diving venture provided the participating agencies an opportunity to make first hand visual comparisons with the customary benthic grab samples. We were especially interested in observing and photographing both the epibenthic organisms and evidence of scour or erosion of sediments.

During a 3-year period from 1967 to September 1970 some 8.2 million cubic yards of silt material from the Providence River were deposited at this site. That operation was the subject of intensive studies by the University of Rhode Island under the direction of Dr. Saul Saila. With the exception of the New York Bight, the Brenton Reef Dump is probably the most thoroughly researched open-water disposal site in the Northeast.

The problem with continued use of Brenton Reef began when Rhode Island fishermen protested further disposal activities there on the grounds that the prolonged periods of turbidity resulting from disposal operations have caused significant reductions in their trawl and lobster pot catches. Another concern, besides possible sediment erosion and transport, was the escape of toxicants from the sediments. In deference to these allegations, the State of Rhode Island recently closed the Brenton Reef grounds indefinitely.

The University of Rhode Island is continuing studies on the recolonization rate of benthic fauna and the life cycles of various amphipod species inhabiting the dredged material at Brenton Reef. Concentrations of selected heavy metals in

[1]See Section 227.63, *Federal Register*, October 15, 1973.



Meter stick with compass attached measures width and direction of current-induced ripple marks in dredged material mound 90 feet down at Brenton Reef dump site.

both the sediments and ocean quahogs are being monitored by the National Marine Water Quality Laboratory.

The appearance of ripple marks and surficial sands at the summit of the dredge material mound indicates that the site is being actively reworked by bottom currents. Underwater observations reveal a sandy lag deposit containing a high percentage of shell has developed over the shallower portions of Brenton Reef. This sandy layer serves to protect or inhibit erosion of the underlying fine sediments and is more attractive to recolonization by shrimp, crabs and other more mobile animals. It is not yet known whether this sand layer will persist or whether there is a net transport effect away from the disposal ground.

Accumulations of soft, flocculent organic muds were noted to be greatest at the deeper depths. With the exception of a few adult cancer crabs found burrowed into the substrate, epibenthic animals (quite predictably) were lacking in association with these fine sediments. A greater diversity and number of organisms occurred in association with the sand-silt bottom types. Some of the more common organisms observed include several shrimp species, tube-dwelling amphipods, adult and juvenile cancer crabs, sponge, ocean quahogs and the smaller bivalved mollusks and hermit crabs. Surprisingly, fish sightings were few despite abundant food sources.

A 10- to 12-foot near-bottom turbid layer was apparent throughout the area, but was noticeably denser over the softer bottoms. This layer appeared to be vertically bounded by the presence of a thermocline.

The diving ship's fathometer detected a rock pile deposited by previous disposal operations which we found, after underwater observations, provided an excellent habitat for lobsters. In fact, lobster boats were observed working the spot during early morning transit to our diving locations. Placement of more rocks would undoubtedly enhance the habitat quality and local lobster population, but would render the location unsuitable for trawl fishing.

If we can use these cursory diving observations as an index, then we can state that recolonization of the disposal site is progressing admirably. However, such findings, while encouraging, only offer a brief glimpse of the true conditions and should not be construed to mean that past disposal operations were accomplished in the absence of any detrimental effects. There are many unresolved questions concerning the fate of heavy metals and organic pollutants contained in the dredged material. A concerted research effort is sorely needed to determine the effects of toxic substances on the metabolism of selected indigenous organisms. Of no less importance is the determination of transfer rates of pollutants between water sediments and biota and also across the thermocline.

Laboratory experiments are currently underway at the University of Rhode Island to determine the effects of known concentrations of silt on lobster. It is essential to know or be able to predict turbidity levels which may inhibit or prevent lobster or fish movement into a given area. This becomes a very important question to answer with regard to the *regional* ocean dump concept.

Applying SCUBA to NEPA

Cooperative diving surveys such as these multiagency efforts are helping to resolve mutual regulatory problems, only one of which is ocean disposal. Combining the scientific disciplines available among several agencies working together can also improve the preparation of impact statements for other types of proposed projects. For example, first hand information produced by divers' observations can offer much that is valuable in evaluating permit applications for deepwater ports, offshore oil drilling and mineral mining, oil refineries and power generating facilities.

Diving is a tool that has only begun to be applied toward attempts to learn more about our marine environment. There are several areas of research which demand our attention and can be accomplished, at least in part, through SCUBA techniques. Improved knowledge of animal-sediment relationships is needed to enable prediction of natural populations from estimates of substrate types. The use of channels or dredged burrow holes by fish and invertebrates requires more thorough investigations. Studies should also be initiated to determine effects of suspended and deposited sediments on coastal marine species under natural habitat conditions.

Scientists familiar with the problems of ocean disposal advocate that further research on ocean dumping effects should be directed towards developing information that will serve to establish criteria not only for the selection of deposition sites but also for dredging operations and dredged material disposal. In general, the research efforts should contribute to the structuring of adequate EIS.

One method of realizing this goal would be to form a joint agency task force composed of environmental professionals from a wide variety of fields. This task force could provide a select group of field specialists on call for short-term team efforts to contend with problems of regional importance. Assignments might include site analysis of a proposed ocean disposal or drilling area. In another case, priority might be given to collecting baseline information and studying selected pristine marine environs which will become subject to construction pressures in the near future. More use of diver observations and underwater photography could lead to more practical recommendations for both forecasting and managing the consequences of future marine engineering activities on underwater regimes. As with any of our natural resources, their proper care can only be ensured when there is a unified effort by all those agencies involved in their protection. The medium is the EIS; the data gathering tool is the SCUBA-equipped diver. ■

Preceding articles on land use in Water Spectrum have been concerned with Federal and State level planning decisions affecting our natural resources. The following discussion introduces an approach for strengthening the planning bond between State and local government.

by Frank R. Leone
Assistant Chief
Division of Planning
Ohio Department of Natural Resources

A State Plan For Lake County

Nearly all controls over land use in Ohio are delegated to local units of government—the townships, counties and municipalities—by the Ohio Revised Code. This delegation of controls makes definition and implementation of a State role in regulating land use a subject to be approached only after careful evaluation of the existing State-local intergovernmental structure.

There is increasing agreement that at least two types of weaknesses exist in the present intergovernmental structure when we talk about land use planning and control. First, local governments find it very difficult to respond to the need to manage and preserve areas of critical environmental concern which are of regional, State or national significance. Second, in most States neither the State nor the local government has the authority to resolve problems caused by the multijurisdictional impacts associated with large scale development activities.

Ohio is pursuing a policy of direct involvement in programs of critical environmental concern, having passed legislation giving the State authority over scenic rivers, natural areas, and the regulation of surface mining for all minerals. Likewise, the Ohio Power Siting Commission has authority to override local governmental decisions on site location of major electric power generation and transmission facilities. Studies now being undertaken on the subject of critical areas should result in the enlargement of a State role in this area, as well as recommendations for additional legislation. The need for such a State role has been explored in previous *Water Spectrum* articles.[1]

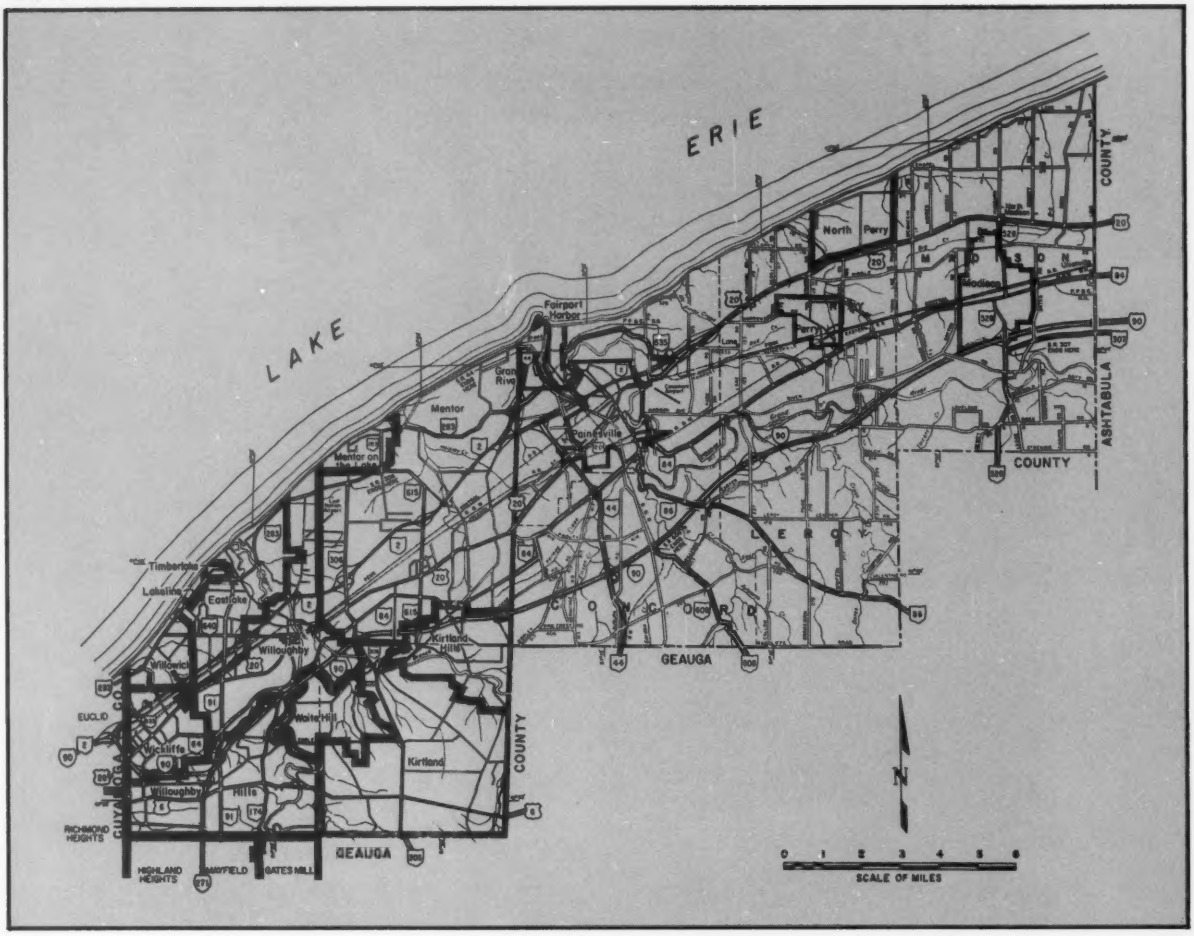
[1]See: "Coastal Zone Management Act: A Broader Scope for State Initiative" by Robert W. Knecht, Vol. 5, No. 1, 1973;
"Land Use" by Lance Marston, Vol. 5, No. 3, 1973;
"Land Use—A Challenge to State Leadership" by R. Deane Conrad, Vol. 6, No. 1, 1974;
"A State's Approach to Land Use" by James R. Hinkley, Vol. 6, No. 2, 1974.

The focus of this article is on a third weakness in the present State-local planning structure—the lack of natural resource based technical information at the intrastate regional and local levels. Such information is essential for effective land use planning; in most States, it can only be provided by State government.

The Ohio Department of Natural Resources is highly visible throughout the State by virtue of its program responsibilities in planning, parks, forestry, wildlife, and reclamation. Such favorable visibility encourages local units of government, concerned citizen groups, and private developers to request advice and assistance in a variety of subject areas. These include:

- the need to slow the conversion rate of Ohio's best agricultural land to higher density development;
- flooding and drainage problems (caused by improper development) ranging from nuisance to property damage and loss of life;
- unhealthy conditions caused by improper location of septic systems, inadequate sewage collection and treatment plants, insufficient water supplies, and poor drainage;
- continual deviation from adopted land use plans to accommodate individual interests;
- rigidity of local use regulations which dictate destruction of landscape features to maintain density standards:
- destruction of landscape features such as historic sites, scenic rivers, and natural areas; and
- construction of large scale facilities in one political subdivision without consideration of their impacts on adjacent jurisdictions.

Grand River still winds through Lake County in its natural state, which the Ohio Scenic Rivers Program seeks to preserve by using land capability analysis to develop a river corridor plan.



The underlying requirement for a meaningful response to such issues is physical data, such as soil surveys, and the ability to interrelate this data in a manner that will identify development problems and determine the relative capability of each land area to handle different land uses.

Comprehensive plans, as well as the day-to-day decisions, by local planning and zoning officials and bodies have often ignored the physical environment in determining where development should take place. These plans and decisions have not considered such physical realities as flood-prone areas, high seasonal water tables, or shallow bedrock, each of which presents its own special problem for housing, industry, or agriculture interests. Consequently, land use planning has often lacked the rational or defensible basis which an evaluation of the physical setting could provide.

For many years the Department of Natural Resources has been gathering data on Ohio's soils, geology, vegetation, water resources, topography, climate, and other characteristics. For soil scientists, mineral geologists, and others trained in the use and application of such specialized data, the information was of great value. Making the collected information readily useful to local planners and officials, however, required a process to integrate the information and link it to the problems of general land use planning and regulation.

This requirement was recognized in 1973 with the establishment of a Division of Planning within the Department of Natural Resources. The new division's primary responsibility was to develop a program, as a service to local governments and planning agencies, which would determine the relative capability and suitability of all land in Ohio to support certain uses. The program which resulted has been called a land capability analysis.

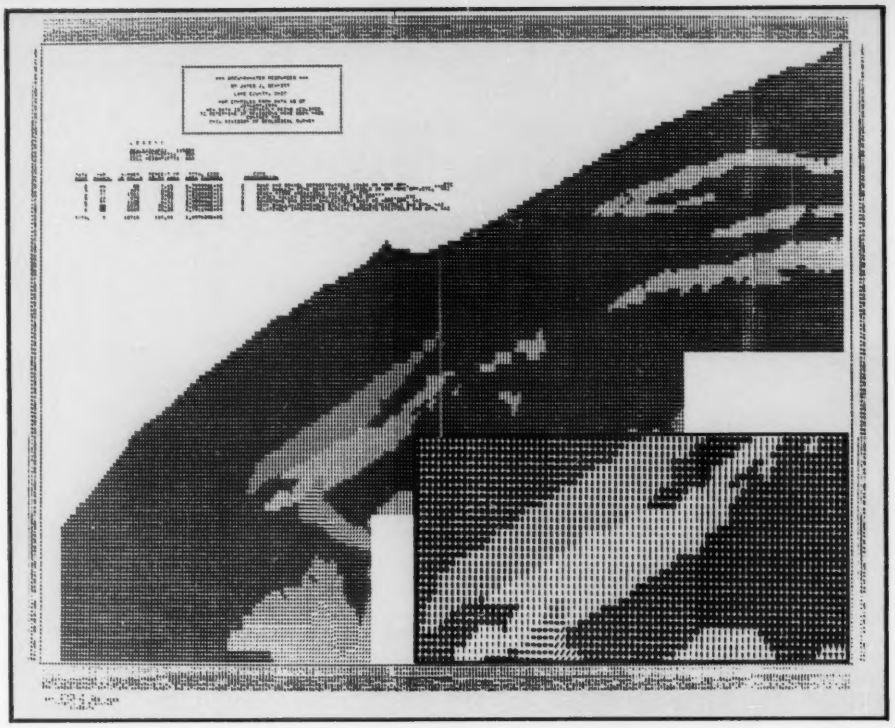
Development of this technical planning assistance program was based on the following guidelines:

- most land use controls should remain at the local level;
- maximum advantage should be taken of the economies of scale, specific expertise, and financial resources of State agencies; and
- state involvement should consist of programs acceptable to local elected officials, staff, and citizens.

While a strong conviction exists in Ohio that local governments should continue to administer most land use controls, this does not mean that State government has no role in land use controls. State government's role in controlling land use should be indirect, by providing assistance in meeting planning goals which tend to base land use decisions on objective facts. The purpose of land use controls is to implement the planning decisions. Ability to make decisions that are based partly on a preceding land capability analysis increases a local

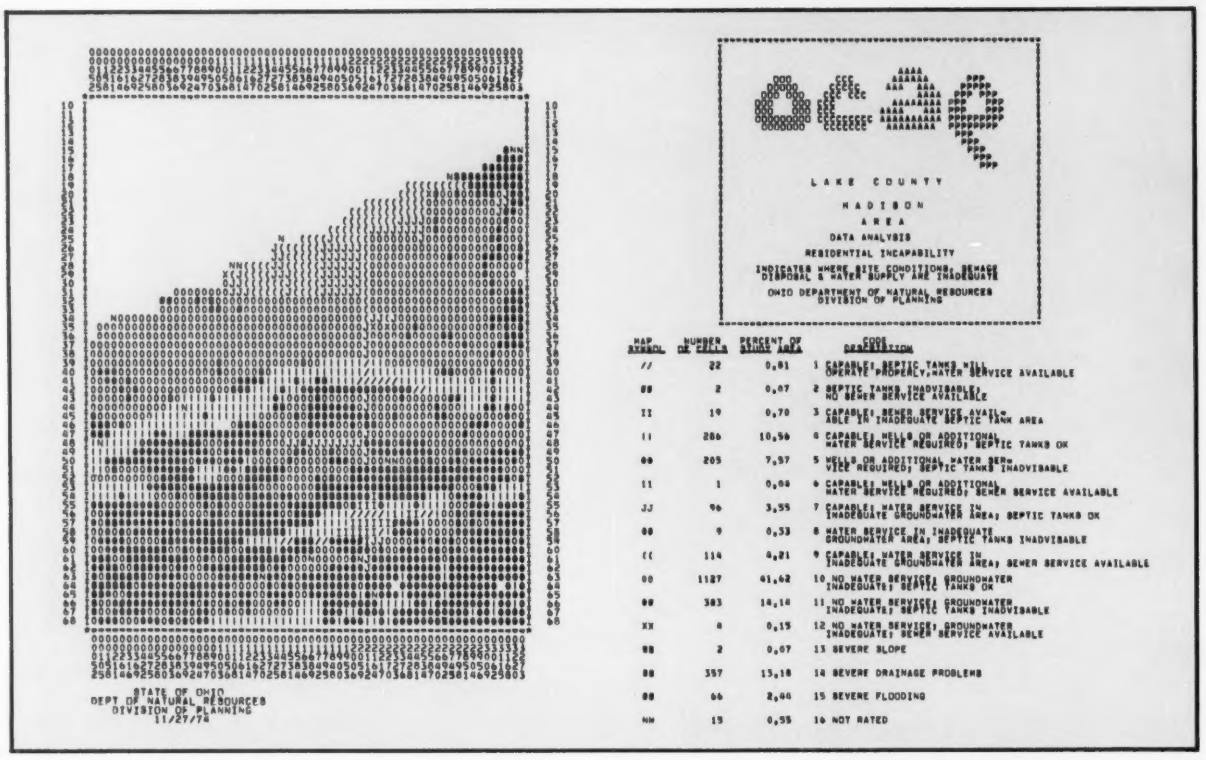
Above—Shore erosion along Lake Erie and flooding are environmentally relevant contraints on future development in the county.

Base map of Lake County, just east of Cleveland, delineates political boundary of OCAP's first completed project.



OCAP map of Lake County's Madison area uses symbols to indicate where site conditions, sewage disposal and water supply are inadequate for residential development.

Data map displays county's groundwater resources in symbolic language.



MAP SYMBOL	NUMBER OF CELLS	PERCENT OF STUDY AREA	CODE	DESCRIPTION
//	22	0,01	1	CAPABLE; SEPTIC TANKS WILL OPERATE PROPERLY; WATER SERVICE AVAILABLE
88	2	0,07	2	SEPTIC TANKS INADVISABLE; NO SEWER SERVICE AVAILABLE
II	19	0,70	3	CAPABLE; SEWER SERVICE AVAILABLE IN INADEQUATE SEPTIC TANK AREA
II	286	10,56	4	CAPABLE; WELLS OR ADDITIONAL WATER SERVICE REQUIRED; SEPTIC TANKS OK
66	205	7,57	5	WELLS OR ADDITIONAL WATER SERVICE REQUIRED; SEPTIC TANKS INADVISABLE
II	1	0,04	6	CAPABLE; WELLS OR ADDITIONAL WATER SERVICE REQUIRED; SEWER SERVICE AVAILABLE
JJ	96	3,55	7	CAPABLE; WATER SERVICE IN INADEQUATE GROUNDWATER AREA; SEPTIC TANKS OK
00	9	0,33	8	WATER SERVICE IN INADEQUATE GROUNDWATER AREA; SEPTIC TANKS INADVISABLE
((	114	4,21	9	CAPABLE; WATER SERVICE IN INADEQUATE GROUNDWATER AREA; SEWER SERVICE AVAILABLE
00	1127	41,62	10	NO WATER SERVICE; GROUNDWATER INADEQUATE; SEPTIC TANKS OK
99	383	14,14	11	NO WATER SERVICE; GROUNDWATER INADEQUATE; SEPTIC TANKS INADVISABLE
XX	4	0,15	12	NO WATER SERVICE; GROUNDWATER INADEQUATE; SEWER SERVICE AVAILABLE
88	2	0,07	13	SEVERE SLOPE
88	357	13,18	14	SEVERE DRAINAGE PROBLEMS
88	66	2,44	15	SEVERE FLOODING
NN	15	0,55	16	NOT RATED

government's ability to regulate land use more rationally. It was such thinking that prompted the Ohio Department of Natural Resources to initiate development of the land capability analysis concept in October 1972. The concept has been defined as a process whereby "the ability of the land to accommodate various land uses without creating significant problems for either the inhabitants of an area or its environment is determined."

The process itself is based on the conclusion that all land uses, regardless of location, make demands upon the natural environment, and that the viability or success of a use in a particular physical location depends largely upon the capability of the environment to sustain it. Capability analysis studies were first applied by the department in preparing a land use plan for Massie Township in Warren County. This project relied on a manual capability analysis method employing transparent overlays for each physical type of variable.

Mentor Marsh is a Lake County site the State wants to incorporate into a system of nature preserves representing Ohio's natural features. These include bogs, swamps, marshes, forests, prairies, geological formations, lakes and streams.

It was obvious, however, that a quicker, more efficient method would be essential to deal with county-sized areas. This realization provided the impetus, early in 1973, to develop a computerized format that came to be known as the Ohio Capability Analysis Program (OCAP). The accompanying software package currently used to perform this capability analysis includes three types of programs. First, we accumulate a storage file of physiographic data to provide the necessary natural resources base. Second, we analyze this data according to the capability functions developed for each land use. Third, we map both the stored data and the information generated by the analysis program in a digitized format.

The goal is to provide this kind of information for each of the State's 88 counties. Fourteen capability analysis programs are underway in Ohio, each varying slightly due to the exact nature of the project area. Suburban Lake County, to the east of Cleveland, is the first project to be completed and will, therefore, be used to illustrate how this concept of technical planning assistance has been incorporated into the existing State-local relationship.

According to the 1970 census, Lake County was the fastest growing county in Ohio over the preceding decade, a population increase of over 72 percent. As county development continues, concerns are being expressed about traffic congestion, poor drainage, and flooding that reflect a growing awareness of the need for careful land use coordination. Local communities are trying to guide this development through modern planning and zoning approaches that recognize their own needs and desires as well as the county's. In this framework a land capability analysis can serve as an important point of reference for reviewing local project proposals and directing the manner in which new growth takes place.

The initial phase of the Lake County capability analysis was development of a work program specifically suited to the county's needs. Cooperative arrangements were formulated among those agencies with responsibility in the study area. In the case of Lake County this includes the Lake County Planning Commission, the Northeast Ohio Areawide Coordinating Agency (NOACA), and the Ohio Department of Natural Resources. Each agency had specific roles throughout the duration of the program. All agencies were involved in the collection and preparation of data.

The county planning staff, in addition, was responsible for specifying the analysis package format (variables, scale, etc.) needed for its ongoing programs. It was also responsible for the development and management of an efficient method for continual updating of the data. The Ohio Department of Natural Resources provided development of all models necessary to fulfill the analysis package requirements, data processing of all information for evaluation by the OCAP program, and all additional requests subsequent to the publication of the final report.

The specific physiographic data variables collected for the Lake County analysis include soils, geology, physiography, hydrology, vegetation, climate, and existing land use. The relevance of each for land use planning follows:

Soils. The soils present may determine drainage conditions, crop fertility, building foundation strength, erosion potential, and the effectiveness of on-site sewage disposal.

Geology. The nature and degree of development occurring in an area depends upon the type and depth of bedrock, the existence of geologic hazards, and the adequacy of local sand and gravel deposits. At present, the most apparent geologic activity in Lake County is the rapid erosion of the shoreline. Another less obvious hazard, the variable nature of the different layers of glacial deposits, results in landslides adjacent to the major, deep stream valleys.

Physiography. The degree of slope is a governing factor in whether a site can be economically built upon, farmed, or crossed by a road. It is also a major component in erosion potential and in the proper operation of septic tanks. Steep hillsides, among the most fragile of stream-related areas, must be properly protected from misuse.

Hydrology. A knowledge of the area drainage system is essential in predicting the possible effects of future development on flooding and pollution of rivers, creeks, and other water bodies. Existing flood-prone areas must be identified and protected from vulnerable and inappropriate land uses.

Vegetation. The nature and extent of vegetation in an area

is an important determinant of wind and water erosion factors, water runoff characteristics, wildlife habitats, and potential recreation sites. Woodland locations also are a factor in analyzing residential capability and site access.

Climate. This is a relatively new consideration in land use planning. Climate data is most useful in analyzing the probable impact of development on runoff and air quality deterioration.

All existing data must be evaluated for suitability. Because of the flexibility of the computer mapping programs, data can be accepted at any scale, thus eliminating the need for time-consuming and costly redrafting. Where existing data needs updating or where new data must be generated, both interpretation of aerial photography and satellite imagery are used. Black and white, low altitude aerial photography at a scale of 1:24,000 is ideal for updating existing land use; and the entire vegetative inventory was also mapped by this method.

This exercise presented an opportunity to compare the use of aerial photo interpretation with the potential use of ERTS imagery (stored in a digital format on computer categorized tapes) for gathering vegetative information. Results of this study indicated using this remote sensing capability is viable for the specialized land cover data built into OCAP. An additional benefit of using ERTS data was the fact that the information was already in a digital format, eliminating the need for additional data processing.

Once all data was collected, the aerial photographs were converted to a digital format for mapping and evaluation by OCAP. All OCAP data files have been organized into 7.5-minute quadrangles at a scale of 1:24,000, corresponding to the U.S.Geological Survey's Topographic Map Series. All data maps and analyses are generated at this scale; however, any scale or boundary (political subdivisions, watersheds) can be

Some county areas may be suitable sites for mineral extraction, others for residential development, and some for no development of any kind.

requested for a specific project.

Compilation of a detailed natural resource data base does not become completely meaningful input into a land use planning process until it can be translated into a form usable by professional planners. Few, if any, regional planning staffs include personnel sufficiently trained in the natural sciences to assimilate this data and adopt it for use in comprehensive land use planning.

To provide this link, the OCAP system includes a set of analysis functions which rates each particular location in a study area in terms of those physical variables significant to the individual land uses in question. These individual ratings for the variables in any one location can then be summed and classified to provide an overall physical capability rating for that location. A residential capability map, for example, would evaluate each location and indicate whether that site had no limitations, few limitations, or severe limitations for the construction of a residential dwelling; also, by evaluating the data, the precise reason for a certain rating can be recognized.

As initially conceived, the physical data base for Lake County was evaluated on a *use*-oriented approach in order to define relative capability ratings for eight land uses: residential, commercial, industrial, agricultural, underground utilities, transportation, recreation, and conservation. The comparison of these relative capabilities, rated by land use, was supposed to provide meaningful input into a plan formulation process.

The Lake County staff, however, requested further refinements in OCAP to assist them in reviewing developments proposed for that county. To fill this need, the analysis would have to set forth clearly the types of concerns it would be reflecting, the nature of any particular site's shortcoming for a proposed development and any areas considered unfit (in an absolute sense) for development. These considerations stimulated conversion of the program to a *problem*-oriented approach. The problem-oriented approach divides concerns according to the areal extent of their impact and the group of people they affect. Three general groups of problems pertain.

On-site problems must be faced by the developer in converting the land to its new use, and by the owner or user after the conversion. On-site problems, in turn, are of two types: (1) installation problems, including such activities as clearing, grading, and excavation, and (2) maintenance problems, such as flooding, poor drainage, and foundation stability. Of course, if severe maintenance problems are indicated for a site, additional measures, at a higher cost, may be necessary at the time of installation. Identification of on-site problems ensures that future users know and can pay all the costs in the beginning and are not faced with unexpected damage or dangers after the developer's liability has expired.

Areawide environmental quality. Site qualities and location can be used to judge whether a particular use on that site may result in environmental degradation elsewhere. This implies the transfer of some material or effect off-site, either by air or water movement or by some visual effect not compatible with surrounding land uses. Erosion, sedimentation, particulate matter fallout, aquifer pollution, and surface mining are all examples.

Resource loss. Development of particularly valuable or unique resource areas (prime agricultural lands, wetlands, wildlife habitats, etc.) for intensive or incompatible uses represents a loss both for those directly affected and for the region or State in general. Governments, acting on behalf of the people, may regulate the conversion and use of such resources. With adequate legislative definitions, the analysis program can identify these areas. For example, some States identify wetlands on the basis of soil drainage and vegetation, while others preserve prime agriculture lands based on soil type and slope definitions. For each of these examples, the analysis program can easily map areas satisfying the criteria.

The problem-oriented functions developed for Lake County include: clearing and grading, excavation, excess water, foundation stability, water supply and wastewater disposal. All locations in the county received numerical ratings for each problem, based upon a standardized scale that permitted direct comparisons among the different problems or functions. The same set of potential problems identified areas in the county that would be incapable of supporting development under normal development procedures. After eliminating those areas incapable of development, the remaining land was evaluated to show where development could most easily or economically be accommodated.

The refinements in the program developed for this Lake County study represent a valuable advance for regional land planning analysis in Ohio. For the first time, thanks to OCAP, planners and local officials have a decision-making tool with which to quickly and comprehensively evaluate the environmental aspects of development proposals. OCAP can identify those areas of the community with the best physical potential for intensive development, as well as significant natural or hazardous locations where development should be avoided. Thus, OCAP can furnish a rational basis for the guidance of community growth in a manner beneficial to both the citizens and the environment.

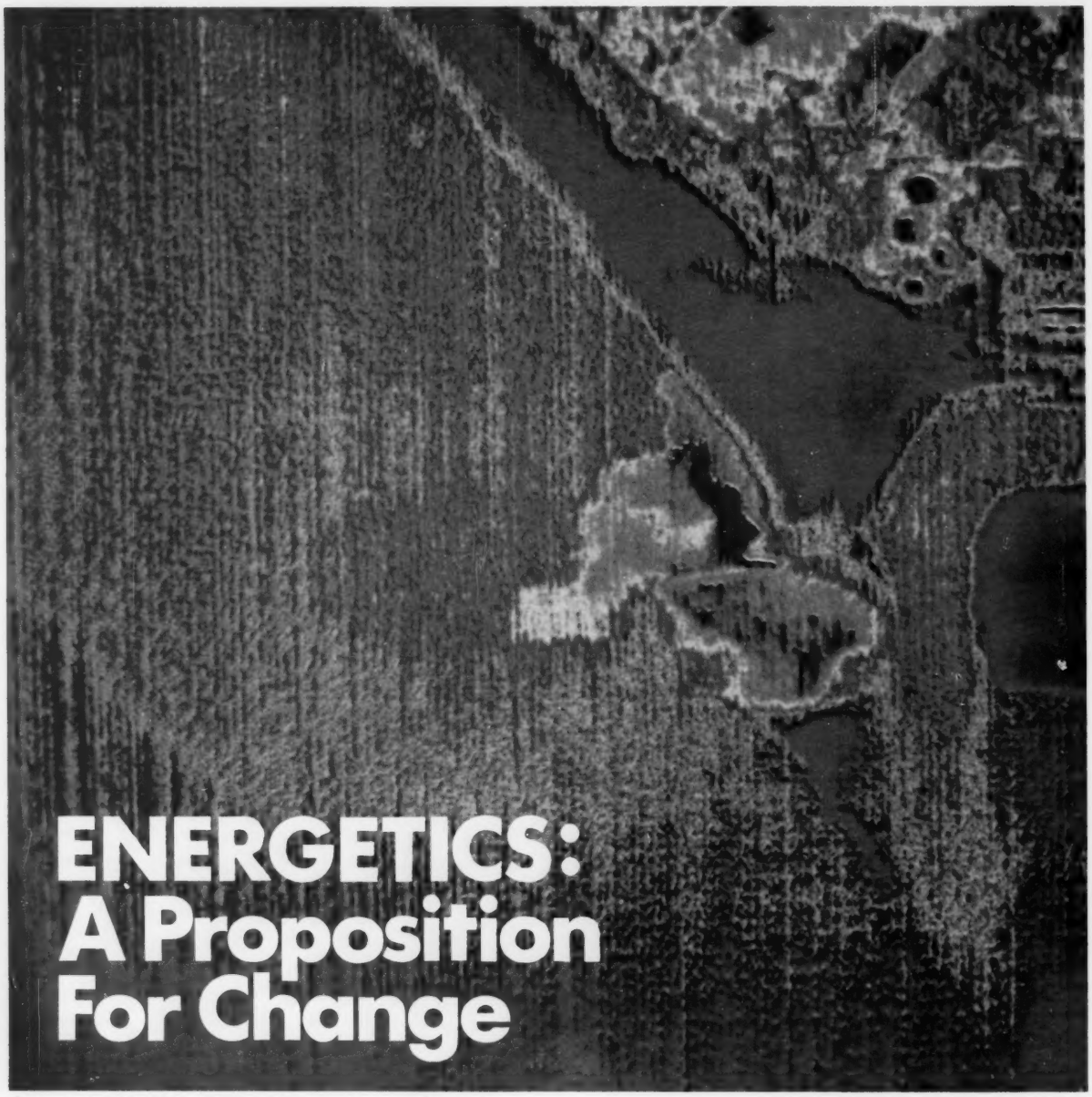
As the Ohio Department of Natural Resources continues with further land capability analysis, changes in problem perception and analytical approach are almost certain. If the last county analysis completed resembles this—the first—OCAP will have fallen short of its potential. The Lake County data base should be readily adaptable for future applications. Such adaptability is essential to a process of this kind, since resource planning cannot be a static exercise.

The department will maintain contacts with the planners and officials of the Lake County area in an effort to examine and resolve questions about the best use of the county's resources. These contacts will also produce valuable information concerning the usefulness of the study's approach and results at the local level. In this way, the future refinement of OCAP can proceed in a direction that is consistent with and most beneficial to the concerns and needs of local government in Ohio.

Technical planning assistance to local government using OCAP has provided a mechanism for State input toward improving land use control mechanisms within the jurisdictions of Ohio's counties, townships, and municipalities. At the same time, OCAP procedures are being used to implement those legislated programs being undertaken at the State level (scenic rivers, natural areas, power plant siting), and to fulfill planning requirements under the Federal Coastal Zone Management Act of 1972. The use of uniform procedures at all intrastate governmental levels not only increases the speed with which a statewide resource data base can be collected, but also provides a measure of coordination necessary for successfully solving the varied land use problems which face Ohio, one of the Nation's most heavily populated and fastest growing States. ■

The Vol. 5, No. 4, 1973 issue of Water Spectrum carried a description of the Corps' "Three-Year Evolution" in learning to respond to NEPA. The last of the three phases identified was integrated planning. *The following article relates energetics to this phase of the evolution.*

by Alex C. Otto



ENERGETICS: A Proposition For Change

Energetics could benefit by measuring the radiant heat loss (entropy) captured in this remote sensing imagery via satellite. Colors represent varying temperatures emitted by natural and manmade earth features.

Preparation of the environmental impact statements resulting from passage of the National Environmental Protection Act (NEPA) has not been an easy task. One of the problems encountered repeatedly in evaluation has been how to include both man's and nature's values together. This problem has been difficult to deal with when we rely on a traditional approach that emphasizes economically oriented techniques which are also used to evaluate the more socially oriented factors.

The exciting prospect of investigating an alternate technique that might overcome some of the current shortcomings in evaluating Corps of Engineers projects has led us to study the possibilities inherent in applying the concept of energetics. This concept was first described by Dr. H. T. Odum, a professor at the University of Florida.[1] His energetics thesis states that it is now possible to apply the basic laws of energy to complex macroscopic man-nature systems; once having done so, the essential features of these systems become subject to precise analysis and evaluation through the use of energy equivalents in such a manner as to confront contemporary environmental and social issues. For example, conclusions resulting from applying an energetics evaluation (by Dr. Odum's team of energetics analysts) to alternative methods for treatment of cooling waters used in a fossil fuel electric power plant in Florida revealed that direct discharge into an existing estuary was (significantly) the least energy consuming and perhaps biologically beneficial. Additional efforts are still being conducted to verify this finding.

Dr. Odum believes his methodology offers natural resource planners an alternative to the traditional economically oriented techniques such as benefit-cost ratio, input-output analysis or the trendline approach. All of these require a compilation of past, present and projected data. However, each lacks the necessary theoretical basis needed to uniformly evaluate the relationship, interaction, impact and complementary values between natural and manmade systems.

When the Corps made its initial efforts to correct this deficiency, the result was the preparation of exhaustively detailed regional environmental inventories. Thus, our first stage of impact statement preparation materialized in the form of lengthy taxonomic lists of flora and fauna. This taxonomic tendency appeared to confuse rather than crystallize relevant factors and, has not proved very useful in evaluation or decision making.

Energetics, however, begins with a precise identification of the existing macroscopic forms of natural ecosystems, human communities, transportation networks and industrial complexes in a chosen region. Relating the relevant factors is achieved by specifying the energy flows along the *interaction arteries* (pathways of energy interchange for work between systems), *dependency linkages* (lines of surplus energy from one system to another system, upon which the survival of the latter is dependent) and *maintenance loops* (flows of energy within or between large and small systems required to maintain the structure, grease the wheels of production, improve efficiency, develop knowledge, perform research, etc.) for that region. When the identification task is completed, the bewildering complexity of the man-nature relationship is reduced to a level capable of human perception and becomes subject to quantitative measurement. Further, the resultant display provided by using this data to draw up a network diagram assists in visually spotting areas where the proposed changes would cause significant impacts.

The difficulty of this task is, of course, not to be underestimated. However, with the emergence of the relatively new science of remote sensing,[2] the task may be reduced to manageable proportions. With the aerial perspective provided by using remote sensing an "energetics analyst" can draw together the complementary data previously available from diverse sources in the form of historical maps, regional inventories, ground surveys, State and Federal statistics, public input, and energy consumption rates.

Implementation

Application of the energetics methodology to specific projects involves five steps:

- description and identification of relevant components
- ecological network diagram
- energy flow diagram
- experimental computer simulation
- simulation model

On the surface, the first step would appear to correspond with the initial steps of other evaluation techniques in its effort to establish a profile of existing conditions in the study area. The difference lies in the energetics analyst's approach to the second and third steps. The data drawn together here is used to develop an ecological network diagram from which he derives an energy flow diagram, which facilitates a quantitative analysis of the system. The following step is a simulation model for developing alternative plans and predicting their impacts on the total environment. Finally, an adequately verified simulation model provides a continuing basis for system management after a project has been completed.

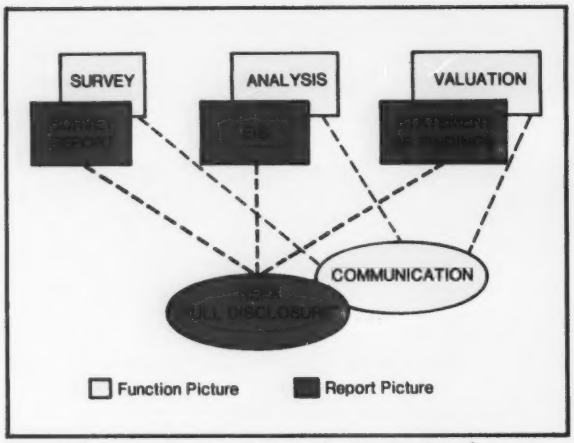
The key to developing an energy flow diagram is to convert the different forms of energy concentrations into a *fossil fuel work equivalent.* This is a value selected for its ability to perform useful work. For example, a calorie of coal is equal to about 2000 calories of sunlight, and it takes 4 calories of coal to equal 1 calorie of electrical energy. The developers of this method assert that all pertinent values in projects dealing with natural resources can be assessed in terms of fossil fuel work equivalents, using the *kilocalorie* as the unit of measure.

Dr. Odum and others proclaim the energy circuit diagram the clearest and most precise technique for discovering and demonstrating the crucial energy relationships within a system. To properly use such a complex diagram, however,

[1]H.T. Odum, *General Introduction: Environment, Power and Society* (New York: John Wiley and Sons, 1971).

Mr. Otto is senior landscape architect in the Environmental Resources Branch, Planning Division, Civil Works, Office of the Chief of Engineers.

[2]Scott C. Sollers, "Nature's Dynamics: An Elevated Perspective," *Water Spectrum,* Vol. 5, No. 4, 1973.



Integrated planning concept requires examination of at least 3 separate documents to provide "full disclosure" under NEPA.

requires a background in the new language symbolism and visual mathematics necessary for this type of analysis. Simplified examples of some appear in the accompanying drawings.

Figure 1 is a somewhat idealized illustration of a complex *farm-city system.* The *farm* and the *city* are the component subsystems. A *money economy* serves as an interdependent linkage between the components, thereby forming the overall system. The flow of money, represented by a dotted line, runs counter to the flow of energy, represented by solid lines. Each of the components has a money and energy storage. These are represented by tank shaped symbols.

Each component has a primary energy source: the farm draws primarily from the sun, the city draws primarily from fossil fuel sources. The interconnection between farm and city, however, is based on a cycle of secondary energy sources which, being of differing qualities, serve special functions within their respective target destinations. Thus, the city supplies various kinds of energies to the farm in technological forms (fuels, chemicals, machinery, etc.) that will increase the latter's productivity. The farm, on the other hand, sends energy to the city in the form of foods.

The money flow is *catalytic,* inasmuch as it facilitates the important secondary energy source flows between farm and city. The city pays for its foodstuffs, the farm pays for its fuels, chemicals, machinery, etc. The ratio of money flowing counter to the energy flow is the *price* of that energy. Since there are two such prices in figure 1, their difference can be viewed as a *balance of payment* measure.

A *processing interaction* takes place inside each subsystem. Incoming primary energy is transformed by specialized production structures (symbolized by interaction arrows) into higher quality energy which goes into storage. The byproduct is waste heat (entropy), which is unavoidable and escapes by way of energy drains or *sinks* (represented by the three lines forming a little triangle). Any secondary energy entering a production structure serves some control function which enhances the basic transformation process. *Feedback loop* energy returning from storage can assist in this control function. Behind this analysis of figure 1 are thermodynamic principles which Dr. Odum refers to as the laws of energetics. Every process, when viewed as a system in itself, involves the importation of energy, the storage of some energy, the degradation or entropy heat loss of some energy and exportation of the balance. Thus, the first law may be stated:

IMPORT = STORAGE + ENTROPY + EXPORT

and a second law as:

ENTROPY is greater than zero for any process.

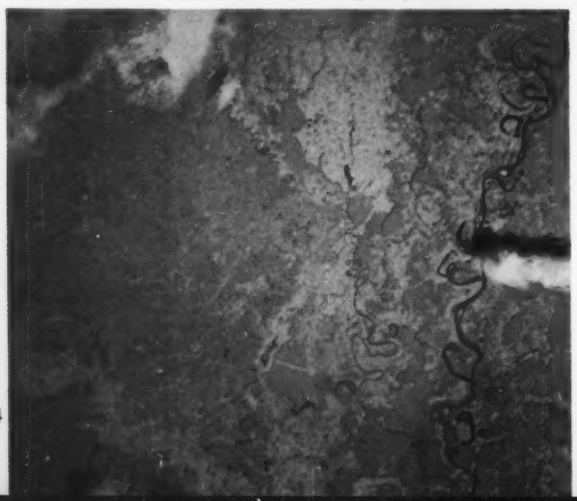
Figure 2 analyzes the farm component of figure 1 in more detail by using imaginary kilocalorie (kc) numbers to express fossil fuel work equivalents. The purpose is to explain the energy constraints imposed on the *accounting procedure* by the basic laws of energetics. Here the total input from external sources is 3500 kilocalories. This is exactly balanced by an output of 3500 kilocalories, composed of 1500 kilocalories exported and entropy losses of 1300, 600 and 100 kilocalories for the various structures involved. Thus, the balanced subsystem resembles a *steady-state* condition. The interaction arrows indicate an internal balance satisfying the first law:

3000 + 500 + 400 = 3900 in
1300 + 600 + 2000 = 3900 out

There are, of course, complications which the above example does not illustrate. However, it does contain the *basic* ideas.

The last two steps show that the obvious mathematical complexity of analyzing and accounting for any real system can be simplified by employment of the computer. Presently, the analog computer is being used because its electrical circuitry relates well to the visual diagramming technique used in the preceding steps. However, speculation has it that a digital computer could be used more effectively on larger, more complex systems. The concept of energetics seems most appropriate to explore at this time, since Corps planners are now thinking in terms of *integrated planning.* Integrated planning, as defined by the Corps, is that reiterative process which incorporates the economic and environmental values of society in developing alternative plans for meeting a set of stated objectives. This is the third phase of a gradual evolution in Corps planning aimed at coping with the environmental and social issues associated with a given project.[3] No longer do we give mere lip service to NEPA as we did in the first two phases, when we *interpreted* the components of the environment and then passed into the *procedural* or letter of the law phase. Environmental impact statements now attempt to follow the intent of the law through *integrated planning.* Hopefully, energetics can contribute to the difficult task of evaluation.

Aerial photography employing remote sensing techniques portrays major part of lower Mississippi Valley's Atchafalaya River basin. This valuable tool can assist in the identification of existing ecosystems.

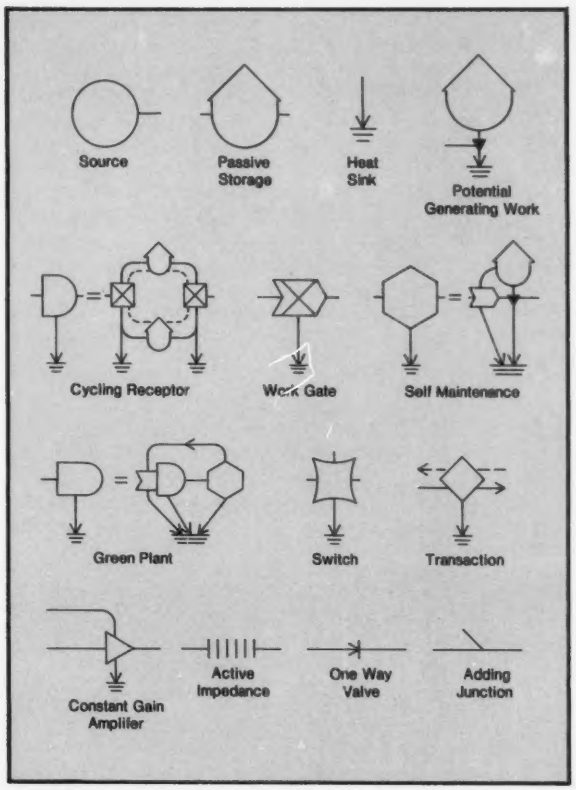


[3]C. Grant Ash, "Three-Year Evolution," *Water Spectrum,* Vol 5, No. 4, 1973.

Criteria

There are a variety of pragmatic criteria against which each method for evaluating project proposals must be measured. These include the following:

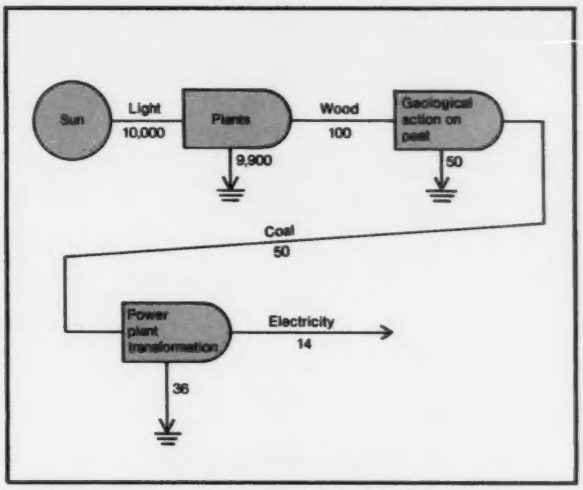
- *Simplicity.* Is this evaluation methodology simple enough for routine work?
- *Adaptability.* Are the parameters and weighting factors employed by this methodology sufficiently adaptable to the kinds of local conditions typically encountered in projects?
- *Freedom from bias.* Is the control or influence factor resulting from internal subjective inputs to the evaluation methodology at a minimum?
- *Responsiveness.* Is the projection of public and community policies and preferences by this methodology at a maximum?
- *Scope.* How useful is the methodology for decision-making throughout the various stages of the planning process?



Example from the dictionary of symbols required for visual mathematics.

It is rather clear that, among other things, integrated planning defines and indeed requires a sound conceptual basis for evaluation of those significant adverse and beneficial effects of Corps projects which are so much at the focus of attention these days.

Since the concept referred to as energetics is a set of ideas oriented towards such evaluation, it has the potential of becoming a methodological component for future integrated planning efforts. Conceivably, the optimal strategy may call for several evaluation techniques comprising a methodological package for the integrated planning philosophy evolved by the Corps from its experience with NEPA.



Dr. Odum's circuit diagram traces energy from its source through 3 levels of conversion. Each change upgrades the quality for mankind, but degrades the amount available through incremental losses to processing.

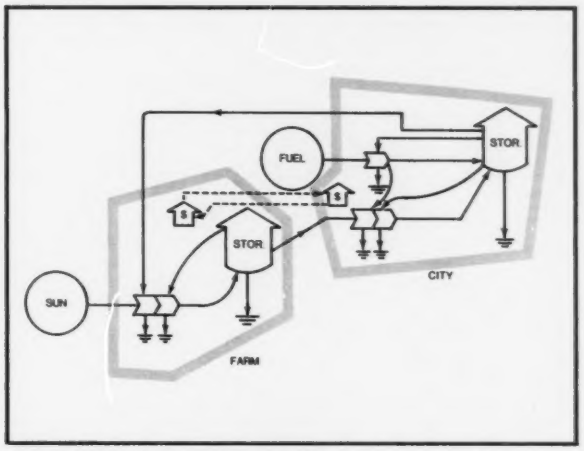


Figure 1. Idealized illustration of a complex farm-city system. Money economy links the 2 subsystems.

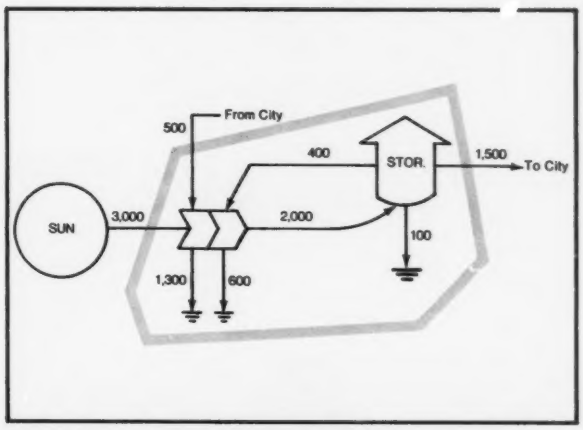
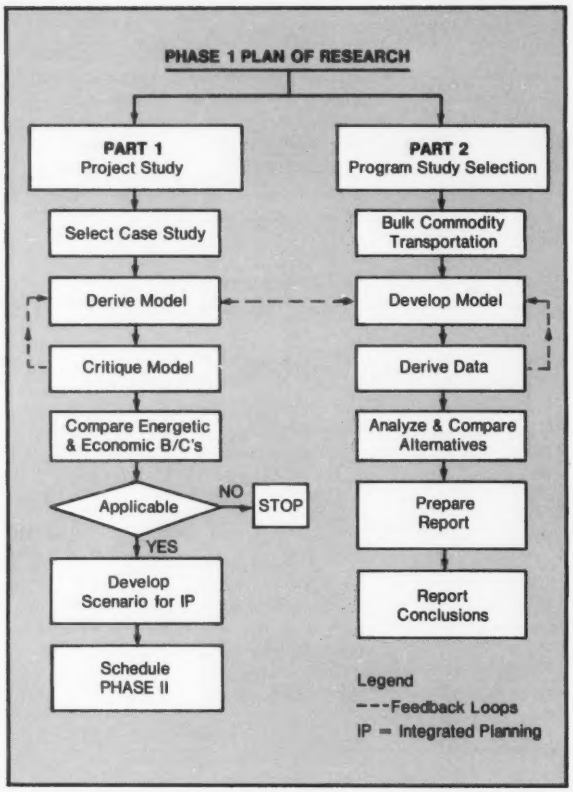


Figure 2. Closeup view of farm component displaying energy flows in fossil fuel work equivalents expressed in kilocalorie quantities.

The Research Plan

The work of Dr. Odum, explained above, may offer the potential for real innovations in project evaluation—one which the Corps plans to research thoroughly in the coming months. Two separate, but parallel, projects are currently under consideration. Each should yield detailed information pertinent to the comparison of energetics with the benefit-cost economic type of evaluation measured against the criteria of integrated planning.

The first is an evaluation of alternative water resource development proposals for the Upper St. Johns River Basin in Florida. The second is oriented toward developing an inland navigation system model which can be used to assess the energy implications of alternative systems for transporting bulk commodities. The procedure for both projects is designed to produce a sequence of interim outputs leading to a final report on how well energetics meets the criteria for integrated planning.



An energetics-based model of a bulk commodity transportation system will be prepared using recent studies of inland navigation systems to compare energetics with an economic analysis of competing transportation modes.

Research utilizing an existing energetics model of the Upper St. Johns River Basin will help to illustrate the following:

- concept and methodology;
- derivation of fossil fuel equivalent factors, energy flow processes, and transformations of key economic and environmental components into energy terms;
- derivation of the energetics model for the basin;
- operation of the model, and
- the means by which basin development alternatives are tested and evaluated.

Speculating on the results this research will produce, it appears that there could be four possible points within the integrated planning process for the entrance of energetics methodology. The first points of entry would be in the form of placing *orders* during the conduct of the data survey and analysis functions. During project formulation energetics could be used to organize the input materials and, during impact statement preparation, to evaluate the anticipated project effects. Extended research might uncover additional points of entry into the integrated planning process.

The other study involves preparation of an energetics-based model of a bulk commodity transportation system which includes barge, rail, truck and pipeline components, at least four commodities (fossil fuels, grain, fertilizer and smelted ores) and a minimum of 10 supply and 10 demand centers. Results of recent economic studies of inland navigation systems will be used to generate a comparison between energetics and economic analyses.[4] This comparison will be used to determine the effects of fossil fuel availability assumptions, population estimates, commodity prices and transportation costs on alternative system configurations of the future.

Results of the Corps' research on Dr. Odum's methodology will not be available until late 1975. Whatever the outcome, the effect of Dr. Odum's work has been to stimulate critical thought regarding current project evaluation techniques. Should it satisfy the criteria of integrated planning, energetics could add considerable scientific substance to the difficult evaluation and decision-making procedures with which Corps planners are increasingly confronted. Like anything new that proposes changing traditional methodology, the concept of energetics will be subjected to much scrutiny and will have to prove itself before being accepted.

In essence, Dr. Odum's philosophy may best be summarized within this quote taken from A.J. Lotka in 1922:

. . .those systems will survive and will outcompete other systems that obtain the largest number of energy sources, and that maximize the flow of useful energy through themselves. . .■

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[4]DuWayne A. Koch, "Tomorrow's Waterways," *Water Spectrum*, Vol. 6, No. 2, 1974.

Events, Deeds & Deliberations

To Virginia Beach With Sand

An estimated 3-year supply of sand for its eroding beaches has been stockpiled for the use of Virginia Beach at adjoining Ft. Story, Va., thanks to the assistance of U.S. Army units from both Ft. Story and nearby Ft. Eustis.

Military bulldozers helped shape the massive 28-acre dune as it quickly built up along the shoreline storage area at Ft. Story. After 2 months of dredging the Thimble Shoal ship channel, some 523,628 cubic yards of medium to heavy course sand awaited hauling away by the resort community. Contractor operated trucks began this part of the operation soon after in preparation for the 1975 tourist season.

Responsibility for periodic dredging of Thimble Shoal channel, which leads into the harbor of Hampton Roads from the juncture of Chesapeake Bay and the Atlantic Ocean, is assigned to the Norfolk District of the Corps of Engineers. Since 1962, the district has also worked with the Virginia Beach Erosion Commission and the city of Virginia Beach in a Federal cost sharing program designed to combat erosion of a 3.3-mile stretch of highly developed resort oceanfront.

This time, however, Col. Robert E. Ayres, the district engineer, decided to attempt combining the dredging and beach nourishment projects. His reasons were based on both environmental and economic considerations. Previously, material dredged from the navigation channel by a seagoing hopper dredge had been dumped at sea, while sand to replenish the beach had been pumped from local lowlands or trucked from upland sites in the area.

Current sources were being exhausted and new source areas were being sought. However, available alternatives looked costly and destructive to the environment. Thimble Shoal channel, on the other hand, was known to contain good, clean sand—some of it washed from the very beach being restored. The answer was to recycle this sand.

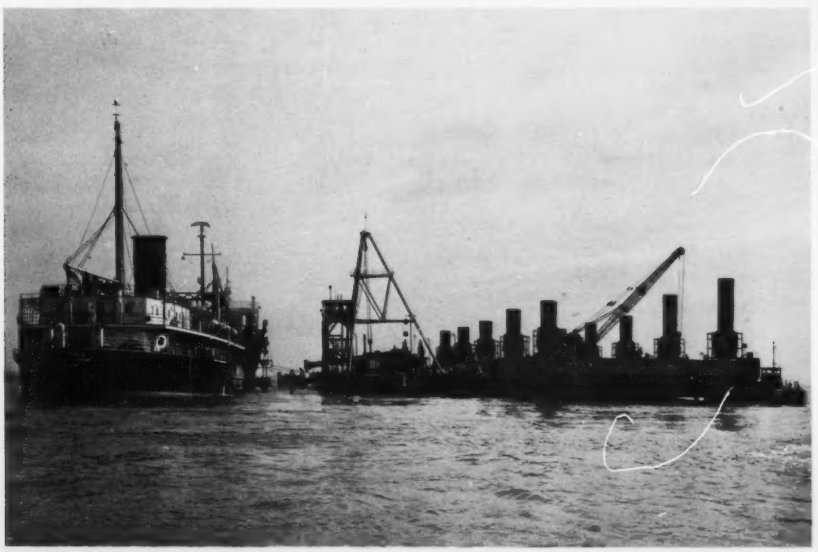
Accomplishing the new objective meant finding a way of transferring the sand from Thimble Shoal to the Virginia Beach oceanfront, a total distance of 10 miles. Since the first 2.5 miles of that distance was over water, it was decided to stockpile a 3-year supply along the shoreline once the necessary equipment and technology could be located.

Previous attempts to pump sand ashore had failed in exposed ocean conditions like those existing at the mouth of the bay. Besides, the 476-foot hopper dredge *Goethals* needed a minimum depth of 30 feet in which to manuever. A means of stabilizing the 60- by 250-foot mooring barge used to connect with the submerged pipeline on one side and linking with the *Goethals* on the other (via a quick-disconnect ring) during the pumpout cycle was necessary to dissipate the effects of the constant wave action in the bay.

The district engineer turned to the 497th Engineer Port Construction Company at Ft. Eustis for use of its DeLong pier. The 80- by 300-foot DeLong pier was towed to the offshore site and then pneumatically jacked completely out of the water via its ten 80-foot long caissons (spuds), thus becoming a true pier several feet above the wave action and providing the required stability. The result was a stable anchorage for the mooring barge, which could operate as an offshore platform where the *Goethals* could hook up to the pipeline for pumping a slurry mix of sand and water ashore. The quick-coupling ring on the mooring barge served to connect the *Goethals* with the offshore end of the 28-inch diameter steel pipeline leading to the Ft. Story sand storage area 1,000 feet away. By reversing its pumping cycle, the dredge was able to pump out each hopper load onto the Ft. Story beach.

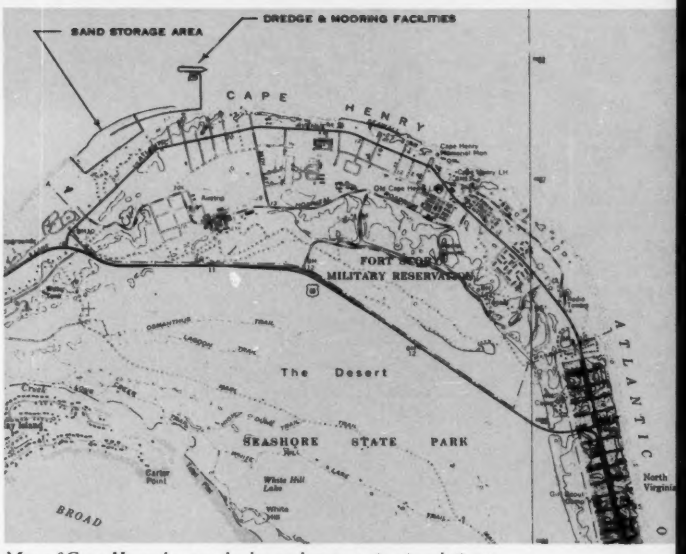
Good weather through most of October and November enabled the *Goethals* to make about 130 dredging cycles on a 6-day week, 24-hour work schedule. Nearly 4,000 cubic yards of sand were deposited on shore after each trip to Thimble Shoal.

Prior to the *Goethals* arrival on site October 1, other elements of the 497th's parent organization, the 7th Transportation Group from the U.S. Army Transportation Center at Ft. Eustis, and the 79th Transportation Battalion stationed at Ft. Story, were ready to support the 60-day dredging and stockpiling operation with the necessary manpower and equipment. This particular type of operation suited the 497th troops quite well. The only port



Its 10 caissons, or spuds, elevate this DeLong pier above the wave action, providing a stable anchorage for the mooring barge in the center. A quick-connect ring on the barge end of the submerged pipeline allows the hopper dredge at left to pump its sand ashore.

Yards of wet sand rise along the Ft. Story shoreline, piped ashore from the hopper dredge working Thimble Shoal ship channel off Cape Henry.



Map of Cape Henry locates dredge and storage sites in relation to Virginia Beach.

A view from the top of the manmade sand dune covering 28 acres of storage area. Visible offshore are the dredge, mooring barge and DeLong pier.

construction company on the Army's active list, the 497th military mission includes construction, improvement and rehabilitation of waterfront facilities—such as piers, wharves and offshore anchorage systems—and the installation of submarine and floating pipelines.

Thus, the Corps was able to involve several active Army units in a meaningful training exercise while accomplishing its necessary dredging and beach nourishment in a single operation. In addition, the Corps was able to test the feasibility of using a DeLong pier in this open sea environment. Although successful, the Corps regards the Thimble Shoal-Virginia Beach operation as an interim solution. Even better would be a system that would permit the *Goethals* to berth alongside a DeLong pier, without using a floating mooring barge. Also, it would be desirable to design the system to provide for pumping sand directly to the city beaches, thereby eliminating the costly truck-hauling between Ft. Story and Virginia Beach, which is included in the Federal cost sharing agreement.

Nevertheless, the results demonstrate that it is feasible to nourish beaches from the ocean floor. During the summer of 1974 sand was pumped successfully onto a Jacksonville, Fla. beach from the relatively protected waters of the St. Johns River. The Virginia Beach success in a less protected offshore environment is encouraging the Corps to consider similar beach nourishment attempts at other Atlantic Coast sites.

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Fish Join Work Force

If research by biologists at the Environmental Protection Agency's laboratory in Duluth, Minn., pans out, a lot of unsuspecting fish may be hooked into the chore of registering complaints about the level of water pollution. In a sense, the fish will be subjected to an invasion of privacy because a monitor will make a polygraph record every time they cough. As the level of pollution rises so does the frequency of fish coughing to clear the pollutant from their gills. Application of the technique may be within reach for industries to measure pollutants in their industrial outfalls.

New Energy Agency

The Energy Research and Development Administration (ERDA), which became operational January 19, 1975, is the new lead agency responsible for solar and geothermal energy research programs. Prior to the existence of the new energy agency, these research programs were under the National Science Foundation's program of Research Applied to National Needs (RANN). RANN energy programs will continue to support advanced and innovative solar and geothermal research, but at a reduced level.

Environmental Snooper Under Study

The development of a portable electronic snooper shows good potential for detecting harmful pollutants in our environment. According to the developers, a biochemist at Michigan State University and chemical industry scientists, the snooping machine has the potential to detect organic pesticides and fertilizer residues and runoffs when they appear in water or the atmosphere. The snooper, which comes complete with advanced electronic components combined with a digital read-out system, is currently under evaluation by Federal agencies for possible field use. If proven effective, the unit could very well become another weapon with which to protect the environment.

That's It

The world's supply of water — about 326 million cubic miles — remains about the same as it was when the earth's atmosphere was formed nearly 3 billion years ago. Although man's use of water continues to expand, the total amount in the world's oceans, its land masses and the air above has neither increased nor decreased.

The Great Death

Samples from the floor of Long Island Sound show the effect of man's dumping on marine life to be relatively minor compared with what several Yale University scientists label the "great death."

The latter appears to be a natural phenomenon characterized by the widespread death of bottom life in a given area. In the case of Long Island Sound, the scientists noticed a sudden change during the summer of 1973 while preparing for a study on the effect of dumping polluted silt into the sound that had been dredged from New Haven Harbor. This phenomenon has been recorded in other bodies of water as well, but the cause is unknown.

By September of 1974 marine life was observed to be returning to normal levels at the four sample sites used in the study. These are the New Haven Harbor, the dump site and two locations chosen for control comparisons. In all four, the death and recovery periods are unrelated to the presence of dredged material, since the dump ground recovered as well as the control sites. In fact, even more marine life has appeared at the dump site during the recovery period, probably because the mounds of silt on the otherwise flat floor of the sound offer a variety of living conditions.

The continuing study includes analysis of marine life tissue for metal content and changes in the chemistry of the dredged material. Eventually, the research team hopes to determine precisely which species are present in what amounts at each study site compared with other areas.

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Windmills are used extensively to pump ground water to surface for livestock in western U.S. See page 19. L. F. Konikow